FINAL

SEEPAGE CHARACTERIZATION WORK PLAN

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

U.S. DEPARTMENT OF ENERGY
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EXECUTIVE SUMMARY

This document presents the Work Plan for the component studies which make up the Seepage Characterization project at the Rocky Flats Environmental Technology Site (RFETS), Jefferson County, Colorado. The purpose of this Work Plan is to describe the studies and to provide the methods, procedures, and rationale used to perform them.

This work is authorized by the U. S. Department of Energy (DOE) under the direction of EG&G Rocky Flats, Inc. (EG&G) Environmental Restoration Program Division (ERPD), as a part of efforts to characterize site hydrogeology. The Seepage Characterization is being performed to assess the nature and occurrence of contamination at selected spring and seep sites associated with the B- and C- Series ponds, and other areas within the Woman Creek, Walnut Creek, and No Name Gulch (also known as "Unnamed Tributary") drainages.

The studies described in this Work Plan are not Resource Conservation and Recovery Act (RCRA) Facility Investigations/Remedial Investigations (RFI/RIs). However, because the studies take place within the boundaries of some of the Operable Units (OUs) at the RFETS, it is anticipated that some of the data resulting from these studies may be used as background and/or supporting information for selected RCRA/Comprehensive Environmental Response Compensation and Liability Act (CERCLA) OU RFI/RIs. Therefore, this Work Plan follows the format given in the Environmental Management Administrative Procedures Manual (APM) (DOE, 1994a), Section 5.03, Rev. 0, RFI/RI Work Plan Development, to the extent applicable.

In keeping with the APM, the introduction gives the objectives of the studies, an overview of the Environmental Restoration Program, the scope of this Work Plan, and regional and site background information. Also in keeping with the APM format, site characterization information is summarized for the various OUs; Data Quality Objectives (DQOs) are discussed; a brief Field Sampling Plan (FSP) is presented; a Quality Assurance Addendum (QAA) is provided; a project schedule is presented; and standard operating procedures (OPs) are discussed.

1.0 INTRODUCTION

The studies associated with this project are being conducted in support of the site-wide hydrogeologic characterization and modeling efforts associated with selected OUs. The Seepage Characterization Program is being performed to assess the nature and occurrence of contamination at selected spring and seep sites associated with the B- and C-Series ponds, and other areas within the Woman Creek, Walnut Creek, and No Name Gulch drainages. Potential surface and groundwater interactions also will be assessed by analyzing the flow and environmental isotope characteristics of individual seeps, and gain and loss surface flow characteristics of Woman and Rock Creeks. The studies associated with the Seepage Characterization are primarily located within OUs 5 and 6 (Figure 1). However, some locations lie in the RFETS' Buffer Zone outside of any OU boundaries (Figures 2 and 3).

1.1 Seepage Characterization Objectives

The primary objectives of the Seepage Characterization program are to assess the nature and occurrence of contamination at selected seep and spring locations; to evaluate surface and groundwater interactions; and to collect basic hydrologic data in support of assessments designed to investigate groundwater occurrence and distribution, and aquifer properties. These objectives will be accomplished by performing the following activities:

- Installation, development and sampling of well points;
- Investigation of stream gain/loss; and
- Monitoring and inventory of site-wide spring/seeps.

The accomplishment of these objectives will support a variety of projects including the OU 5, 6, and 7 Remedial Investigations, the 1995 Aquifer Testing Program, the Site-Wide Groundwater Flow Model, the 1995 Environmental Isotope Project, the OU 5 Surface Water Model, the 1995 Ecological Monitoring Program (aquatic biota), the Site-Wide Water Budget Project, and the Site-Wide Hydrogeologic Characterization. The objectives of each activity are described below in more detail.

1.1.1 Well-Point Installation and Sampling

The well-point program is being implemented to support four independent activities which in turn support RFETS hydrogeologic characterization, modeling and water budget efforts. These activities include:

- an evaluation of contaminant nature and occurrence at selected seep locations in OUs 5 and 6;
- expansion of the existing well network to provide improved control of the alluvial potentiometric surface for calibration of the site-wide numerical flow model;
- installation of multiple-well observation wells at existing well sites in Woman and Walnut Creek valley fill alluvial materials for aquifer testing purposes; and
- installation of well points along the Site east boundary (Indiana Street) to provide additional saturated thickness control for water budget calculations.

<u>Seep Contamination Detection</u>

OU 5 and 6 project staff are concerned about potential contaminant migration from the adjacent OUs. Data is currently unavailable along most intervening hillslope areas. Seeps in these areas have been selected for investigation because they represent areas of groundwater flow that are potential migration pathways. The location of well points at seeps also virtually eliminates the possibility of dry wells which have been a problem at other hillside investigations (OUs 1 and 5) due to the complexity of saturated conditions on the hillsides.

Seep locations which occur above the B-Series ponds, as well as other areas within Woman Creek and Walnut Creeks (see Figures 2a and 2b) are targeted for investigation. These seeps will be investigated by installing and sampling small-diameter (up to 0.5-inch (in)) well points driven at each location.

Improved Potentiometric Control

Well points intended to provide additional control of the alluvial potentiometric surface are proposed to fill in strategic gaps in our knowledge of the shallow groundwater flow system. This activity is based in part on a request from DOE (G. S. Hill, written communication, 1994) to provide additional data for groundwater modeling purposes. The information to be provided by these well points is critical for specifying boundary conditions (unsaturated areas) and calibration criteria (saturated areas) for site-wide groundwater modeling activities.

Aquifer Testing

The Woman and Walnut Creek valley fill alluvium represent the primary lateral groundwater flow path for the off-site migration of contaminants, yet the hydraulic characteristics of these deposits below the terminal ponds are essentially unknown. The installation of well point observation wells at existing well sites supports aquifer testing activities planned for 1995. The performance of short-term (<24 hour) aquifer pumping tests using driven well point observation wells (2 to 3 per site) will generate a more reliable estimate of hydraulic conductivity compared to single well tests. It is expected that these measurements will verify the high hydraulic conductivities normally assumed for modeling applications and groundwater velocity calculations, and constrain the range of values used for future pathway analyses.

Water Budget Calculations

Efforts are currently underway by EG&G Environmental Protection Management Department, Surface Water Branch, and EG&G Environmental Restoration Management Department to perform a site-wide water balance in support of a water rights evaluation. The east boundary of the study coincides with the section of the east property boundary located approximately between State Highway 128 and a low topographic divide which separates Woman Creek from the unnamed tributary containing the D-Series ponds. This boundary currently lacks sufficient well control for estimating the cross-sectional saturated thickness, especially in areas containing alluvial valley fill. The data collected under this activity, in combination with the aquifer pumping test results, will provide for a more reliable estimation of the total groundwater flux (discharge) at the plant downgradient boundary, and thus reduce the amount of uncertainty associated with the water balance calculations.

1.1.2 Stream Gain/Loss Monitoring

The objectives of the stream gain/loss investigation are threefold as follows:

- to support Woman Creek (OU 5) surface water flow modeling efforts;

- to collect baseline flow data in Rock Creek to evaluate surface/groundwater interactions related to potential geologic and hydrologic controls; and
- to provide data related to identifying and assessing the presence and influence of evaporitic and imported water sources in the upper reaches of Woman and Rock Creeks using environmental isotopes, specifically oxygen-18 and deuterium.

Woman Creek Monitoring

Stream gain/loss monitoring has been conducted previously in Woman Creek to gain an understanding of groundwater/surface water flow interactions for flow modeling purposes. This investigation also provided information useful for site-wide hydrogeologic characterization activities. The results indicated the potential for providing additional groundwater data using a more detailed monitoring network designed specifically to assess groundwater inputs to Woman Creek, especially in the reaches of the stream above Pond C-2. The work outlined in this Work Plan will specifically evaluate the potential significance of geologic controls on groundwater discharge to surface water, such as the Laramie/Fox Hills subcrop located at the west boundary of the RFETS. Data will also be used to account for anomalous stream inputs located upstream of previous streamflow monitoring network studies.

Rock Creek Monitoring

Little data currently exists that characterizes the water resources of this area. Monitoring of stream flows along Rock Creek is planned to more adequately and quantitatively define the distribution, importance, and seasonality of groundwater baseflow on stream flows within the drainage as part of site-wide hydrogeologic characterization efforts. Together with the seep inventory, this activity will help establish baseline conditions in an undisturbed watershed that is potentially threatened by active and proposed mining operations, and the new RFETS landfill, and serve as a benchmark for understanding natural surface water/groundwater interactions.

Environmental Isotope Sampling

Sampling for environmental isotopes, especially oxygen-18 and deuterium, will be conducted to identify stream reaches which potentially receive a significant portion of water from evaporitic or imported sources. Data from Rock Creek will also be used to establish isotope background conditions for comparison to Woman and Walnut Creeks and associated tributaries. This technique has already been successfully used to establish hydraulic communication between Rocky Flats Lake and the Antelope Springs complex. It is hypothesized that a similar situation may exist in Rock Creek considering the presence of several large mine pit ponds to the west. Identification of evaporitic water in stream tributaries or seeps could locate areas potentially impacted by mining and could provide a basis for locating future habitat study sites. In areas where the component of evaporitic water is significant, it may be possible to estimate the amount of water contributed from the evaporitic source using mixing equations. Detection of leakage from the South Boulder Diversion Canal into Woman Creek will also be attempted using environmental isotopes as tracers based on measured differences in isotopic content between canal water and local groundwater (canal water has an oxygen-18 content that is 2 to 4 per mil lighter than groundwater).

1.1.3 Seep Inventory and Monitoring

Like the stream gain/loss investigation, there are three main objectives of the site-wide spring/seep inventories and monitoring activities. These include:

- preparation of a comprehensive seep map from field observations and published reports;
- collection of basic flow and field water quality data and cataloguing seep occurrences by flow characteristics, seep type, probable geologic source, areal extent, and other relevant parameters determined from field observations, measurements and published reports; and
- monitoring of selected springs on a biweekly to monthly basis to establish seasonal variations in flow and water quality in conjunction with aquatic biota monitoring, and provide flow data in support of the stream gain/loss project.

Seep Map

Despite the existence of various historical and recent wetlands, vegetation and hydrologic maps, there is currently no comprehensive, field-verified map of RFETS which exclusively and accurately identifies and delineates seeps caused by natural groundwater discharges based on hydrologic criteria. Seep maps generated to date have been limited in areal extent (e.g., OU 2) or based on aerial photography with limited verification. An accurate seep map is not only relevant for understanding current-day groundwater occurrence, flow and direction, but together with wetlands mapping, provides a baseline for assessing the potential future impacts of industrial activities and water diversions on water resources within the Site boundary.

Seep Data Collection and Cataloguing

Except in certain cases (e.g., Antelope Springs) basic hydrologic information on spring and seep occurrences and characteristics at RFETS is generally lacking. This study will systematically collect flow and field water quality data on an estimated 200 seeps during high and low flow conditions on a reconnaissance basis in support of site-wide hydrogeologic characterization efforts. Seep occurrences will be catalogued by flow characteristics (perennial, intermittent, channelized, diffuse, etc.), seep type, probable geologic source, areal extent, and other relevant parameters determined from field observations and published reports (e.g. Corps of Engineers (COE) Wetland Study). In addition, environmental isotope sampling (oxygen-18, deuterium and enriched tritium) will be performed at seeps occurring in the Industrial Area and upper reaches of Woman and Rock Creeks for identifying potential evaporitic or imported water sources as described above in Section 1.1.2.

Seep Monitoring

Frequent monitoring of selected individual springs will be performed to better define seasonal spring flow and field water quality characteristics, and provide flow data for the stream gain/loss and aquatic biota monitoring programs. These sites are primarily located at groundwater discharge areas associated with potential contaminant sources, such as the new landfill and the east end of the 881 Hillside french drain, or significant surface flow discharges associated with major springs.

1.2 Coordination with Other Programs and Investigations

Information from various previous and existing programs and investigations were used to prevent duplication of activities, develop monitoring locations, select analytical parameters and establish seep inventory criteria. A summary of the programs and investigations reviewed is provided below:

Previous Investigations

1) Surface water sampling locations and results from the 1989 Site-Wide Surface Water and Sediment Geochemical Characterization Report (DOE, 1991) were considered in developing the stream and seep sampling rationale.

2) Results from environmental isotope analyses of groundwater and surface water samples presented in the 1995 Groundwater Geochemistry Report (DOE, 1994a) were used to support the analytical rationale.

3) Stream flow locations and results from the 1993 Woman Creek Gain/Loss Study were used to develop stream monitoring locations along Woman Creek (Fedors and Warner, 1993).

4) Wetlands locations identified in the U. S. Army Corps of Engineers Wetlands Mapping and Resource Study (ACE, 1994) were used to plan site-wide seep inventory activities.

5) Monitoring well locations posted as of December 1, 1994, on the 1995 Well Location Map (DOE, 1995b) were used to select well point locations for improved potentiometric control and water balance calculations.

Existing Programs

1) Sampling locations for surface water samples proposed for the OU 12 Technical Memorandum No. 1, Industrial Area Surface and Sediment Field Sampling Plan,

Addendum to Phase 1 RFI/RI Work Plan, January 1995, were considered in support of the seep sampling rationale.

2) Review of surface water sampling locations for continued monitoring under decontamination and decommissioning currently being performed by EG&G Surface Water Division as part of the Industrial Area Interim Measure/Interim Remedial Action (IM/IRA) will be used to support seep inventory activities.

3) Results of the 1993 Site-Wide Groundwater Modeling Activities Report and 1994 Well Evaluation Report were considered when locating additional well points for model calibration purposes.

4) Aquifer pump testing locations selected by the 1995 Aquifer Testing Program provided the basis for approximately 25 well point locations.

5) Results of chemical analyses from monitoring wells associated with the OU 2 east trench area and OU 6 B-Series ponds support the sampling locations and analytical rationale for seep well point locations in Walnut Creek.

6) Routine seep monitoring locations were selected in consideration of stream gain/loss study objectives and in cooperation with the EG&G Environmental Protection Management Department (EPMD) Ecological Monitoring Program.

7) Sampling locations for seep samples collected under the OU 2 RI/RFI were considered in support of the seep sampling rationale.

1.3 Environmental Restoration Program Division

The DOE/Rocky Flats Field Office (DOE/RFFO) Environmental Restoration Program Division is designed and tasked with providing programmatic support to the ER Major Systems Acquisition Division (MSA). The MSA Division is charged with investigation and cleanup of RFETS and meeting Interagency Agreement (IAG) Milestones for its Operable Units. The IAG is an agreement between the Colorado Department of Public Health and the Environment (CDPHE), the United States Environmental Protection Agency (EPA), and DOE. The cleanup of environmentally contaminated sites at DOE facilities are being implemented in five phases (DOE, 1986a). Phase 1 (Installation Assessment) includes preliminary assessments and site inspections to assess potential environmental concerns. Phase 2 (Remedial Investigations) includes planning and implementation of sampling programs to delineate the magnitude and extent of contamination at specific sites and evaluate potential contaminant migration pathways. Phase 3 (Feasibility Studies) includes evaluation of remedial alternatives and development of remedial action plans to mitigate environmental problems identified in Phase 2 as needing correction. Phase 4 (Remedial Design/Remedial Action) includes design and implementation of site-specific remedial actions selected on the basis of Phase 3 feasibility studies. Phase 5 (Compliance and Verification) includes monitoring and performance assessments of remedial actions as well as verification and documentation of the adequacy of remedial actions carried out under Phase 4. Phase 1 has been completed at the RFETS (DOE, 1986a). The Seepage Characterization study sites are located in the RFETS Buffer Zone. Some locations fall within OUs, primarily OUs 5 and 6 (Figure 1). The Remedial Investigations (RIs) for OUs 5 and 6 are nearing completion and the draft RFI/RI reports and Feasibility Studies (FSs) are in progress.

1.4 Work-Plan Scope

Characterization activities covered by this Work Plan are being conducted to provide additional data to site-wide hydrogeologic characterization efforts. Data collected as a result of these studies will be provided to OU managers as supplemental information. However, these studies were not intended or designed to be a part of any specific RCRA/CERCLA OU RFI/RI process. Documents specific to individual OU RFI/RI investigations should be referred to when OU-specific RCRA/CERCLA information is needed. All work performed under this Work Plan will be in conformance with all applicable RFETS policies and OPs.

1.5 Regional and Plant Site Background Information

The RFETS, (formerly known as the Rocky Flats Plant (RFP)), is a government-owned, contractor-operated facility, which is part of the nationwide Nuclear Weapons Complex. The plant was operated for the U.S. Atomic Energy Commission (AEC) from its inception in 1951 until the AEC was dissolved in January 1975. At that time, responsibility for the plant was assigned to the Energy Research and Development Administration (ERDA), which was succeeded by DOE in 1977. Dow Chemical U.S.A., an operating unit of the Dow Chemical Company, was the prime operating contractor of the RFP from 1951 until June 30, 1975. Rockwell International was the prime contractor responsible for operating the RFP from July 1, 1975 until December 31, 1989. EG&G became the prime contractor at the RFP on January 1, 1990. The official name of the RFP was changed to the RFETS in the summer of 1994 to more accurately describe the current mission of this facility.

Plant Operations

Historical operations at the RFETS consisted of fabrication of nuclear-weapons components from plutonium, uranium, and other nonradioactive metals (principally beryllium and stainless steel). Parts made at the RFETS were shipped elsewhere for assembly. In addition, the RFETS reprocessed components removed from obsolete weapons for recovery of plutonium. Other activities at the RFETS included research and development in metallurgy, machining, nondestructive testing, coatings, remote engineering, chemistry, and physics. Both radioactive and nonradioactive wastes were generated in the production process. Current waste handling practices involve onsite and offsite recycling of hazardous materials, onsite storage of hazardous and mixed wastes, and offsite disposal of solid radioactive materials at another DOE facility. However, the RFETS operating procedures historically included both onsite storage and disposal of hazardous, radioactive, and radioactive mixed wastes. Preliminary assessments under the ER Program identified some of the past onsite storage and disposal locations as potential sources of environmental contamination.

Previous Investigations at the RFETS

Various studies have been conducted at the RFETS to characterize environmental media and to assess the extent of radiological and chemical contaminant releases to the environment. The investigations performed prior to 1986 are summarized in the Geological and Hydrogeological Data Summary (DOE, 1986b).

In 1986, two major investigations were completed at the RFETS. The first was the ER Program Phase I Installation Assessment (DOE, 1986a) which included analyses and identification of current operational activities, active and inactive waste sites, current and past waste management practices, and potential environmental pathways through which contaminants could be transported. A number of sites were identified that could potentially have adverse impacts on the environment. These sites were designated Solid Waste Management Units (SWMUs) and were divided into three categories (DOE, 1987):

1) Hazardous waste management units that will continue to operate and need a RCRA operating permit;

2) Hazardous waste management units that will be closed under RCRA interim status; and

3) Inactive waste management units that will be investigated and cleaned up under Section 3004(u) of RCRA or CERCLA.

The IAG redefines the SWMUs within the second and third categories as Individual Hazardous Substances Sites (IHSSs). IHSS is used hereinafter; however, no RCRA or CERCLA regulatory distinction in the use of the terms "site" or "IHSS" is intended in this document. Previous investigations specific to site-wide geological information are detailed in the Geologic Characterization Report (DOE, 1991a).

Physical Setting

Location

The RFETS is located in Sections 1 through 4, and 9 through 15, of Township 2 South, Range 70 West of the 6th Principal Meridian, in northern Jefferson County, Colorado, approximately 16 miles northwest of Denver. Nearby cities include Boulder, Westminster, and Arvada, which are located less than 10 miles to the northwest, east and southeast, respectively. The cities of

Golden and Lakewood are located approximately 15 miles directly south of the RFETS. The RFETS property consists of approximately 6,550 acres of federally-owned land, 400 acres of which is located within the RFETS security area where most major buildings are located. The security area is surrounded by a buffer zone of approximately 6,150 acres. The northern boundary of the property sits on the county line between Jefferson County and Boulder County. The property is bordered on the north by State Highway 128, on the east by Jefferson County Highway 17 (Indiana Street), on the south by agricultural and industrial properties and State Highway 72, and on the west by State Highway 93. Access to the property is via State Highway 93 or Indiana Street.

Topography

The RFETS is located along the eastern edge of the southern Rocky Mountain region immediately east of the Colorado Front Range. The RFETS is at an average elevation of approximately 5,950 feet above mean sea level. The site is located on a broad, eastward-sloping alluvial surface. The surface of the alluvium is nearly flat but slopes gently eastward at 50 to 100 feet per mile (DOE, 1991a). At the RFETS, the alluvial surface is dissected by a series of east-northeast trending stream-cut valleys. The valleys containing Rock Creek, North and South Walnut Creeks, and Woman Creek are cut 50 to 200 feet below the level of the older alluvial surface in the vicinity of the RFETS.

Meteorology and Climate

Climate

The climate at the RFETS is strongly influenced by the Front Range of the Rocky Mountains. Dry, cool winters with some snow cover and warm, moderately-moist summers characterize the Rocky Flats climate. The temperatures average a maximum of 76°F and a minimum of 22°F, with an average annual mean temperature of 49.6°F. The temperature extremes recorded at the RFETS range from 102°F in July to -26°F in January (Schleicher and Schuell, 1982). Infrequent cloud cover over the region allows intense solar heating of the ground surface during the day, and the low absolute humidity allows significant radiation cooling at night. The average relative humidity was 46 percent for the period between 1954 and 1976 (DOE, 1989).

The regional topography and upper-level wind patterns over North America create a semi-arid climate along the foothills of the Front Range. Average annual precipitation is approximately 15 inches (DOE, 1991b). The maximum annual precipitation, recorded in 1969, was 24.87 inches. More than 80 percent of the precipitation at the RFETS occurs as rain between April and September, with the remainder of the precipitation occurring as snowfall in the winter months (DOE, 1989). Snowfall at the RFETS commonly occurs during the months of November through March, although occasional snowstorms occur in April, May, September, and October.

Local Meteorology

Local meteorology is influenced by local topography, mountain ranges, and large-scale weather systems. The orientation of the bordering mountain range, as well as the general orientation of the Front Range of the Rocky Mountains play an important role in determining the wind regime.

The RFETS is in the belt of prevailing northwesterly winds which are normally channeled across the geological bench called Rocky Flats.

Local mountain and valley features exert a strong influence on the wind flow under other meteorological conditions. When winds above the gradient level are strong and from a direction slightly north of west, channeling in the eastern Rocky Flats bench usually continues to produce northwesterly winds over most of the RFETS. On clear or partly cloudy nights, the valley experiences rapid surface radiational cooling. This results in simultaneous cooling of the air near the surface which causes the air to become stable and less turbulent. However, air along the slopes of the Front Range cools at a faster rate than air at the same elevation located over the valleys. Consequently, it becomes more dense and flows or sinks toward the valley forming a down-slope wind. When this wind reaches the valley, it still flows toward lower elevations and becomes a down-valley wind.

Meteorology of the RFETS is strongly influenced by the diurnal cycle of mountain and valley breezes. The Front Range west of the RFETS, is broken by several canyons that run generally east-west. These canyons also serve to channel airflow, especially when there is strong atmospheric stability. Two dominant flow patterns exist, one during daytime conditions and one at night. During daytime hours as the earth heats, the mountains receive more direct sunlight than the plains and valleys, causing air to heat and rise. The result is a general trend for the airflow to travel toward the higher elevations (upslope condition). The general airflow pattern during upslope conditions for the Denver metropolitan area is typically north to south, with the airflow moving up the South Platte River Valley and entering the canyons into the Front Range.

After sunset, air against mountainsides cools and begins to flow toward the lower elevations (downslope conditions). The airflow pattern for the Denver area during downslope conditions is down the canyons of the Front Range onto the plains. This airflow converges with the South Platte River Valley airflow moving toward the north-northeast (DOE, 1992a).

Strong convective activity and thunderstorms are common in the area during summer. This activity can produce severe anomalies on the normal airflow patterns because of strong inflow regions or outflow microbursts caused by the accompanying rain shafts. During late winter and spring, the meteorology can be influenced by chinook windstorms. The chinook phenomenon is characterized by strong winds moving from the west to the east over the continental divide. These winds often reach 70 to 80 miles per hour (mph) and have been recorded in excess of 120 mph at the RFETS (Rockwell, 1989). The mean wind speed for 1990 was 9.0 mph with the highest wind speed reported at 88.6 mph (DOE, 1991c).

Precipitation

Precipitation in the RFETS area primarily occurs as snowfall or short-duration thunderstorms. These localized thunderstorms are generally one hour or less in duration, and their areal extent is usually limited to approximately one square mile. RFETS precipitation data are collected and recorded at the West Buffer Zone Meteorological Station. Over the long term, the average annual precipitation at the RFETS has averaged nearly 15.2 inches (DOE, 1991b). Although the RFETS-site-specific data are limited, annual evaporation at the RFETS site is estimated to be between 31 and 38 inches, based upon long-term records at Cherry Creek Dam and the City of Fort Collins, respectively (DOE, 1991b). The Cherry Creek Dam is located in the Denver metropolitan area approximately 25 miles southeast of the RFETS, and Fort Collins is located approximately 45 miles north of the RFETS. These two sites are meteorologically similar and therefore the evaporation rates are considered representative of the RFETS evaporation rates.

Surface Water Hydrology

Three streams -- Rock Creek, Walnut Creek, and Woman Creek -- are the primary drainages for the RFETS area and flow generally from west to east. Figure 1 provides an overview of the surface-water features in the vicinity of the RFETS. Rock Creek drains an area of the RFETS buffer zone generally to the northwest of the RFETS Controlled Area, flowing into Coal Creek offsite to the north. The Rock Creek drainage is located in the north part of the RFETS. Coal Creek flows west and north of the RFETS and is joined by Rock Creek northeast of the RFETS. Coal Creek flows into Boulder Creek, then St. Vrain Creek, and eventually the South Platte River. Walnut Creek is formed by the combined flows from North Walnut Creek and South Walnut Creek, which drain the central and northern areas of the RFETS, respectively, along with an unnamed tributary, referred to as No Name Gulch, draining a northern part of the RFETS area (Figure 1). These three tributaries join in the buffer zone, and Walnut Creek flows towards the Great Western Reservoir to the east. However, Walnut Creek flows generally are diverted around Great Western Reservoir into Big Dry Creek through the Broomfield Diversion Ditch. Rock Creek, North Walnut Creek, South Walnut Creek, and No Name Gulch are all intermittent streams; that is, flows occur in these streams primarily as a result of spring-season snowmelt and after precipitation events.

Woman Creek, also an intermittent stream, originates to the west of the RFETS, drains the southern RFETS area, and flows eastward (Figure 1). The South Interceptor Ditch (SID) is located between the RFETS Controlled Area and Woman Creek; collects runoff from the southern part of the RFETS and diverts this to Pond C-2. Waters from Pond C-2 are pumped, treated, and discharged into Walnut Creek downstream of the eastern the RFETS boundary. Most of the remaining surface-water runoff in the Woman Creek drainage downslope of the South Interception Ditch drainage flows offsite to the east and in part into Mower Reservoir and primarily into Standley Lake.

Eight ditches convey water throughout the general RFETS area: South Boulder Diversion Canal, Last Chance Ditch, Upper Church Ditch, McKay Ditch Bypass, Smart Ditch, Smart 2 Ditch, Mower Ditch and Kinnear Ditch. The Upper Church Ditch, McKay Ditch Bypass, Kinnear Ditch, and Last Chance Ditch all divert water from Coal Creek to the east; the Smart Ditch diverts water from Rocky Flats Lake to the east; and the Smart 2 Ditch diverts water from the Smart Ditch to a Woman Creek tributary. The Mower Ditch diverts water from Woman Creek into Mower Reservoir. The South Boulder Diversion Canal is located west of the RFETS and is unlined in the vicinity of the RFETS, except for a cement-lined 100-meter aqueduct that crosses the Woman Creek drainage. All other irrigation ditches within the RFETS referenced above are unlined and tend to lose water through seepage into the underlying subsurface materials.

In addition to the ditches described above, other surface-water management controls also are in operation at the RFETS. The West Interceptor Canal diverts runoff from the headwaters of North Walnut Creek via the McKay Ditch Bypass to Walnut Creek west of Indiana Street. In addition to ditches and canals, a series of detention ponds have been constructed to control the release of the RFETS discharges and to collect surface runoff.

Ecology

The plant communities in the Buffer Zone appear to have a diversity of plant species, reflecting the wide range of habitats available at RFETS. Dominant species, based on herbaceous production data, vary considerably among the RFETS study sites (DOE, 1993a).

The small mammal community is dominated by the deer mouse (*Peromyscus maniculatus*) in all habitats. A new species has also been captured, the olive-backed pocket mouse (*Paragnathus fasciitis*), as well as a single Preble's Meadow jumping mouse (*Zaps hudsonius preblei*), a Colorado Species of concern (DOE, 1993a).

At this time, no effects on Buffer Zone ecosystems due to RFETS activities have been documented. The preliminary picture of the RFETS is that of a healthy, diverse, protected area that supports a unique combination of fauna and flora in the Front Range region (DOE, 1993a).

Surrounding Land Use and Population Density

The population, economics, and land use of areas surrounding the RFETS are described in a 1989 Rocky Flats vicinity demographics report prepared by DOE (1991d). This report divides general use of areas within 0 to 10 miles of the RFETS into residential, commercial, industrial, parks and open spaces, agricultural and vacant, and institutional classifications and considers current and future land use near the RFETS (DOE, 1992a; 1992b; 1993b).

The majority of residential use within 5 miles (8 kilometers) of the RFETS is located northwest, west, southwest, and south of the RFETS. Commercial development is concentrated near the residential developments around Standley Lake, primarily north and southwest, and around the

Jefferson County Airport which is located approximately 3 miles (4.8 km) northeast of the RFETS. Active industrial land use within 5 miles (8 km) of the plant is limited to quarrying and mining operations located on lands directly west and southwest of the RFETS. There are several pockets of industrially-zoned property located around the RFETS, both directly adjacent and nearby. This property is not likely to be developed in the near future due to a lack of water for fire protection. These properties must be accepted into a fire protection district in order to be developed for commercial or industrial use and no fire protection district is willing to accept the properties at this time. Open space lands are located northeast of the RFETS, near the City of Broomfield, and in small parcels adjoining major drainages and small neighborhood parks in the cities of Westminster and Arvada. Standley Lake is surrounded by Standley Lake Park. Irrigated and nonirrigated croplands, producing primarily wheat and barley, are located northeast of the RFETS near the cities of Broomfield, Lafayette, and Louisville; north of the RFETS near Louisville and Boulder; and in scattered parcels adjacent to the eastern boundary of the RFETS. Several horse operations and small hay fields are located south of the RFETS.

Future Population and Land Use Projections

Future land use in the vicinity of the RFETS will probably involve continued suburban expansion, increasing the density of residential and commercial and industrial land use in the surrounding areas. The expected trend in population growth in the vicinity of the RFETS is addressed in the DOE demographics study (DOE, 1991d).

Regional Geology and Hydrogeology

The RFETS is located on gravelly alluvium that covers an eastward-sloping pediment surface. Bedrock is exposed locally along streams that have dissected the pediment. The groundwater is recharged by infiltration of rainfall, snowmelt, stream seepage, and irrigation water into the surficial materials and bedrock. Groundwater flow within the RFETS area generally is in the direction of the slope of the ground surface, primarily eastward. Discharge from the surficial materials is via springs and seeps along valley walls near the bedrock contact. Discharge from shallow bedrock is to the eastward flowing streams that dissect the alluvium covered pediment.

Surficial Deposits

The surficial deposits covering the pediment surface in the immediate vicinity of the RFETS comprise the Rocky Flats Alluvium. This alluvium is Quaternary in age and was deposited as an alluvial fan with its apex at the mouth of Coal Creek Canyon transported as outwash located five miles to the west at higher elevations in the Front Range (Baker, 1973). It is composed of poorly- to moderately-sorted, poorly-stratified clay, silt, sand, gravel, and cobbles. The coarse clastic materials were derived primarily from Front Range provenance areas, which are composed of Precambrian crystalline metaquartzites, metabasalts, pelitic shists, and younger granitoids of the Boulder Creek and Silver Plume Granites.

The Rocky Flats Alluvium is the surficial material beneath nearly all structures at the RFETS, where the alluvium thickness ranges up to 100 feet. The alluvium is absent where it has been removed by downcutting of the streams (Walnut Creek and Woman Creek) in the vicinity of the RFETS. The depositional surface declines approximately 300 feet from the western edge of the

RFETS peripheral buffer zone to the eastern edge of the buffer zone. This distance is 3.4 miles, and the slope is 88 feet per mile.

Local colluvial deposits are present on steeper slopes flanking drainages at the RFETS. These deposits are derived from Rocky Flats Alluvium located upslope. Most bedrock is concealed beneath the colluvial material. The bottoms of the stream valleys contain Quaternary alluvium deposited by the streams. Minor linear wetlands are present on these alluvial materials (DOE, 1991a).

The dominant soil developed on the Rocky Flats Alluvium is the Flatiron Series. These soils are sandy loams with a large percentage of cobbles. They have a slow infiltration rate where slopes are 0 to 3 percent. Nederland Series soils are also present and consist of sandy loams with a large percentage of cobbles. They are preferentially developed adjacent to the Flatiron Series along the periphery of the Rocky Flats Alluvium where slopes are 15 to 50 percent and have a moderate infiltration rate. A third soil is the Denver-Kutch-Midway Series. These soils are clay loams developed on Arapahoe/Laramie Formation claystones with slopes of 9 to 25 percent. The preceding information regarding soils at and adjacent to the RFETS is derived from Soil Conservation Service (SCS, 1980). Presently these natural soils are partly obscured by fill, gravel, and buildings at the RFETS.

Bedrock Geology

The upper Cretaceous Arapahoe/Laramie Formation unconformably underlies the surficial material at the RFETS. This formation was weathered and eroded during the formation of pediments and eventually covered by the Rocky Flats Alluvium. According to the Geologic Characterization Report for the RFETS (DOE, 1991a), the Arapahoe Formation is 150 feet thick beneath the central portion of the RFETS. However, the position of the Arapahoe/Laramie Formation contact is being evaluated. Results from a recent surface mapping project (DOE, 1992c), suggest that the Arapahoe Formation is generally less than 50 feet thick. The lithologic composition is mainly claystone and silty claystone with sandstone bodies present. Most of the sandstone is very fine to medium fine grained, poorly to moderately but occasionally well-sorted, subangular to subrounded, silty and clayey. Some coarse-grained to conglomeritic sandstone is present. The sandstone bodies are thought to be lenticular and laterally discontinuous. The Arapahoe Formation at the RFETS has been interpreted as channel, point bar, and overbank deposits of a fluvial system (DOE, 1991a).

The Laramie Formation conformably underlies the Arapahoe (Weimer, 1973), and it is approximately 800 feet thick at the RFETS. The formation is divided into two intervals: a lower unit of sandstone, siltstone, claystone with coal layers; and an upper claystone unit (DOE, 1991a). The sandstones are fine to coarse grained, poorly sorted, subangular and silty. The upper interval is about 500 feet thick at the RFETS, consisting of light to medium gray kaolinitic claystones with some dark grey to black carbonaceous claystones (DOE, 1991a). The Laramie Formation originated in a delta plain depositional environment.

The regional structural setting of the RFETS is on the western flank of the Denver Basin, approximately four miles east of steeply-dipping strata on the west flank of the Front Range uplift. The most prominent feature is a monoclinal fold which strikes roughly north-south. The bedrock dips steeply eastward in the west portion of the RFETS, as shown by the 50 degree dip of the Fox Hills and Laramie Formations. The bedrock then flattens to a dip of no more than 1 to 2 degrees. The western portion of the RFETS bedrock contains outcropping sedimentary strata which exhibits dips of up to 50 degrees in the Fox Hills and Laramie Formations. These formations then flatten to a dip of no more than 1 to 2 degrees beneath and east of the plant.

Hydrogeology

The RFETS is situated in a regional groundwater recharge area. The groundwater system is dynamic with rapid changes in the level of the water table in response to short-term stresses to the groundwater system. Generally, water levels are highest in early summer (June) and lowest during the winter months.

Hydrostratigraphic Units

The following paragraphs briefly describe the hydrostratigraphic units in the vicinity of the RFETS. These units include the water table aquifer and confined aquifers.

Water Table (Unconfined) Aquifer

The water table (unconfined) aquifer at the RFETS is primarily the unconsolidated alluvial material. It includes the Rocky Flats Alluvium, which is present on broad topographic highs, colluvium along valley slopes, and the Valley Fill Alluvium present in modern stream drainages. In the western part of the RFETS, where the thickness of the alluvial material is greatest, the depth to the water table is 50 to 70 feet below the surface. Although the water table depth is variable, it becomes shallower from west to east as the alluvial material thins. In the stream drainages, seeps are common at the base of the Rocky Flats Alluvium (DOE, 1991a) and where individual Arapahoe/Laramie Formation sandstones crop out.

Generally, the groundwater flows along the contact of the unconsolidated material and the Arapahoe/Laramie Formation claystones in a downgradient direction to the east. The claystones have a low hydraulic conductivity, on the order of 1×10^{-7} centimeters per second (cm/s) (DOE, 1991a; 1992d), effectively constraining much of the flow within the water table aquifer to the alluvial material above the alluvium/bedrock unconformity. Locally, however, a hydraulic connection exists between the uppermost Arapahoe/Laramie Formation sandstone unit and the surficial materials allowing the bedrock groundwater to become part of the water table aquifer for a limited area. The lower sandstones of the Arapahoe/Laramie Formation also subcrop beneath alluvium and colluvium along valley slopes, therefore also existing as part of the water table aquifer in limited areas.

Confined Aquifers

Groundwater in the sandstone units of the Arapahoe/Laramie Formation occurs under confined conditions over most of the RFETS. The confining layers for the sandstones are claystones and silty claystones.

The Laramie/Fox Hills aquifer crops out at the west end of the RFETS and dips at 45 to 50 degrees to the east. Gradually the dip decreases to less than two degrees beneath the central part of the RFETS where the Laramie/Fox Hills is separated from the RFETS activities by several hundred feet of claystone (DOE, 1991a; 1991c). The claystone is an aquitard which separates the RFETS activities from the Laramie/Fox Hills aquifer.

Recharge and Discharge

At the present time, groundwater recharge is believed to occur as infiltration of precipitation to confined aquifers where bedrock crops out in the western portion of the RFETS along the west limb of the monoclinal fold and to the unconfined aquifer through unconsolidated material and subcropping permeable bedrock throughout the area. Recharge is also believed to occur as a result of infiltration of surface water from streams, ditches, and ponds. At the local level, there are areas of discharge as well as recharge. Baseflow of the intermittent streams is sustained by groundwater discharge. Additionally, groundwater within the surficial materials and underlying permeable bedrock (Arapahoe/Laramie sandstones) discharges at seeps along slopes in the valleys and becomes surface water or evaporates.

Hydraulic Conductivities

The Arapahoe/Laramie Formation and the alluvial hydrostratigraphic units at the RFETS have relatively low hydraulic conductivities and therefore, are not generally believed to be capable of producing amounts of water of economic significance (DOE, 1991a; 1991c).

Aquifer tests conducted in OU 2 in 1992 indicated hydraulic conductivities of 4.6 to 6.1 x 10^{-4} cm/s for Arapahoe/Laramie Formation sandstones and 8.7 x 10^{-4} to 1.8 x 10^{-3} cm/s for Rocky Flats Alluvium (DOE, 1992d). An aquifer test conducted near Woman Creek in OU 1 indicated a relatively high hydraulic conductivity of 1.8 x 10^{-2} cm/s for the Valley Fill Alluvium. The Rocky Flats Alluvium of the uppermost hydrostratigraphic unit has a measured hydraulic conductivity of roughly 6 x 10^{-5} cm/s. This value is comparable to the hydraulic conductivity of 8 x 10^{-5} cm/s for the highly-weathered and unconsolidated subcropping Arapahoe sandstone which also forms a part of the uppermost hydrostratigraphic unit in some locations. Both of these values are much greater than the hydraulic conductivities of the Arapahoe/Laramie claystones which are approximately 1 x 10^{-7} to 1 x 10^{-8} cm/s for both weathered and unweathered claystone (DOE, 1991a; 1991c).

In the subsurface, confined hydrostratigraphic units in the lower Arapahoe/Laramie Formation have hydraulic conductivities of approximately 1 x 10^{-6} cm/s. This value is intermediate to those of the hydrostratigraphic units in the Rocky Flats Alluvium and weathered subcropping Arapahoe/Laramie sandstones and the Arapahoe/Laramie claystones (DOE, 1991a; 1991c).

1.6 Work Locations and Site Descriptions

Activities associated with the Seepage Characterization include stream-flow gain/loss monitoring, inventories and monitoring of spring and seep locations, and well-point installation, development and sampling.

Monthly measurements of stream-flow discharges at selected locations within the RFETS property boundaries in the east Buffer Zone will be performed. These locations will be primarily in the drainages of Woman and Rock Creeks (Figure 3). Twenty-eight stream gain/loss measurement sites have been established on Woman Creek between the RFETS West Boundary and Indiana Street. New gain/loss measurement points will be established in Woman Creek and Rock Creek between the RFETS boundary and State Highway 128.

Two comprehensive site-wide spring and seep inventories will be conducted throughout the buffer zone (Figure 1). Regular monitoring at selected seeps and springs identified in the inventories will also be performed. The purpose of the site-wide inventories is to determine the relative flow and general water-quality and isotope characteristics of individual springs and seepage areas at the RFETS.

Well points will be installed, developed, and sampled in the lower reaches of Woman Creek and Walnut Creek, as well as along No Name Gulch, to provide water-level and water-quality data at stream bottom and seep locations. Parts of these drainages are located within the boundaries of OU 5 (Woman Creek Drainage) and OU 6 (Walnut Creek Drainage). No Name Gulch is located in the east Buffer Zone to the north of the OU 6 boundary (Figure 2a).

Some spring and well locations at RFETS are located in areas of potential or known soil and/or groundwater contamination. In addition, seepage areas are potentially sensitive habitats that may require special precautions to minimize surface damage during intrusive field investigations.

1.7 Project Staffing and Responsibilities

Study-Team personnel include personnel affiliated with the primary subcontractor and its subcontractors. Key positions and responsibilities are described below:

The *Project Manager/Senior Hydrogeologist* provides project management in the form of project budgeting, planning, scheduling and general management. Additional responsibilities include:

- serving as the primary liaison between the Contract Technical Representative (CTR), the Subcontract Administrator (SA), and the primary subcontractor;
- maintaining all project records and providing the SA and CTR with project-status reports;
- coordinating all field and office tasks from the mobilization phase through final reporting; and
- supporting field activities in the role of field hydrogeologist.

The *Field Supervisor/Geophysicist* serves as the Field Supervisor for field activities associated with the Seepage Characterization. Also serves as a field geologist for the installation of well points.

The *Site-Safety Officer (SSO)* implements the Site-Specific Health and Safety Plan (SSHSP) and verifies compliance with all applicable health and safety requirements. Additional duties include:

- ensuring that updated copies of the SSHSP, the SSHSP addendum, Environmental Management Radiological Guidelines (EMRGs), and all documents referenced by the EMRGs are available to employees;

- supervising the Health and Safety Specialists (HSSs) in the performance of their responsibilities and ensuring that HSSs and other employees are advised of the radiological hazards, both expected and suspected, by posting and controlling areas according to EMRG instructions;

- performing audits and surveillances of field activities;

- ensuring that Health and Safety Practices (HSP) 18.19, "Criteria and Actions for Potential Intakes," is adhered to for the duration of the project;

- verification that performance testing of EG&G-owned instruments has been conducted in accordance with the manufacturer's recommendations and ensuring that the test results are recorded daily in a calibration log specific to each instrument;

- reviewing and approving completed survey reports and forms and ensuring that approved surveys and forms are forwarded to the Environmental Management Radiological Engineer (EMRE); maintaining a file of all completed Radiological Survey Forms; ensuring that the EMRE is immediately contacted when survey results indicate radiation levels that exceed five millirem/hour; and

- ensuring that an Instrument Field Log Book is maintained which documents the specific equipment used at the work site.

The *Senior Quality Assurance (QA) Officer* provides QA oversight to all aspects of the project.

The *Subtask Manager/Senior Engineer* serves as subtask manager for the Stream Gain/Loss Monitoring and Reporting and the Site-Wide Spring/Seep Inventory, Data Analysis and Reporting subtasks in support of the Seepage Characterization.

The *Data/Sample Manager* serves as the Data and Sample Manager for the project. In addition, this position will also provide general field support associated with the collection of data.

The primary subcontractor will use secondary subcontract support services for activities requiring special equipment and/or services. These activities are:

- Drilling related to well point installation,
- Well point borehole surveying, and
- Health-and-Safety Specialist support.

2.0 SITE CHARACTERIZATION

2.1 Site Characteristics

The following paragraphs are very brief summaries of the OU 5 and 6 sites. Documents specific to the individual OU investigations should be referred to when more detailed information is needed.

2.1.1 OU 5

Eleven sites, geographically located along or within the drainage areas of Woman Creek have been designated as OU 5 (DOE, 1994b). These IHSSs include the Original Landfill (IHSS 115); the Ash Pits, Incinerator, and Concrete Wash Pad (IHSSs 133.1 through 133.6); Detention Ponds C-1 and C-2 (IHSSs 142.10 and 142.11); and a Surface Disturbance (IHSS 209). Ponds C-1 and C-2 are the only IHSSs located on Woman Creek. The remaining IHSSs are located along the banks and/or upland areas that drain into Woman Creek or into the SID. In addition to these IHSSs, two additional surface disturbances are being evaluated in the Phase I OU 5 RFI/RI, a Surface Disturbance West of IHSS 209 and a Surface Disturbance South of the Ash Pits (DOE, 1994b).

<u>IHSS Descriptions and Histories</u>

The following paragraphs summarize the locations and physical features of each of the OU 5 IHSSs. These discussions are based on the information provided in the OU 5 Work Plan (DOE, 1992b) and Technical Memorandum (TM) No. 15 (TM15) (DOE, 1994b). TM15 contains additional information that was obtained during the course of the investigation of the IHSSs as set forth in the OU 5 Work Plan. This investigation provided clarification regarding the location, description, and history of the IHSSs. These references contain details of the information and data summarized in the following sections on OU 5.

IHSS 115 (Original Landfill) and IHSS 196 (Filter Backwash Pond)

The Original Landfill is located within the buffer zone just south of the RFETS industrialized area and south of the west access road. It is located north of Woman Creek on a moderately to steeply sloping south-facing hillside. The Original Landfill was in operation from 1952 to 1968 and was used to dispose of general wastes generated at RFETS.

IHSS 133 (Ash Pits, Incinerator, and Concrete Wash Pad)

The Incinerator, Ash Pits, and Concrete Wash Pad are located south-southwest of the industrialized area of RFETS, south of the west access road and north of Woman Creek. The locations of these IHSSs are defined from historic aerial photographs. The Incinerator, which had a 10- to 20-foot stack, was located along RFETS's original west boundary, off the west access road. The Ash Pits are located to the east, and Concrete Wash Pad is located southwest of the Incinerator. Ash Pits 1, 2, 3, and 4 (IHSSs 133.1, 133.2, 133.3, 133.4) are approximately 8 feet wide by 150 feet long and 3 feet deep. However, these Ash Pits may be larger as the exact boundaries and dimensions of each unit are somewhat undefined. The four Ash Pits are located on a relatively flat surface and are currently covered by tall grasses.

The Incinerator was used to burn general RFETS wastes between the 1950s and 1968. Depleted uranium also is believed to have been burned in the Incinerator. A review of aerial photographs revealed that by 1971, the Incinerator had been removed and the entire area had begun to revegetate.

The history of the Concrete Wash Pad has not been as well documented as the Ash Pits or Incinerator area. It appears that this area was used to dispose of waste concrete from the concrete trucks involved in the construction activities of RFETS. It is also likely that the concrete trucks were washed down in this area after delivering concrete.

The history of the Ash Pits, Incinerator, and Concrete Wash Pad is not entirely known because few records were kept of their operations. It is known that general combustible wastes from RFETS were burned in the Incinerator, along with an estimated 100 grams of depleted uranium. The ashes from the Incinerator were disposed in the Ash Pits. At the Concrete Wash Pad, potentially contaminated materials consist of concrete debris and occasional ashes from the Incinerator that were reported to have been pushed over the side of the hill onto the Concrete Wash Pad area.

IHSS 142.10 and 142.11 (C-Series Ponds)

Pond C-1 (IHSS 142.10) and Pond C-2 (IHSS 142.11) are located along Woman Creek, southeast of the industrialized area of RFETS and within the Buffer Zone. These ponds are approximately 2,000 feet apart, with Pond C-1 to the west of Pond C-2. The estimated capacities for Pond C-1 and Pond C-2 are approximately 750,000 gallons and 2,480,000 gallons, respectively.

The natural drainage of Woman Creek has been somewhat modified in the OU 5 area by the construction of Pond C-1 and Pond C-2 and the SID south of RFETS. Currently, Woman Creek flows eastward through OU 5 in its natural stream channel to Pond C-1. Filter backwash water from the water treatment facility was discharged in Pond C-1 during the time period between RFETS start-up in 1952 and December 21, 1973. In addition, cooling-tower blowdown water was discharged to Pond C-1 until the latter part of 1974. In the early 1970s, RFETS operations were changed and Pond C-1 was used principally to manage the surface water runoff in the Woman Creek drainage. Water is seldom retained within this pond as the outlet or gate is usually open and the water is allowed to flow through the pond. The water consequently flows in its natural channel until just west of Pond C-2 where it is diverted around Pond C-2 by a diversion canal. During low flows, all of the water is diverted from Woman Creek's main channel at a location downgradient and to the east of Pond C-2, into an unnamed ditch that flows into Mower Reservoir. During high flows, some flow continues to flow downstream in Woman Creek and into Standley Lake.

In 1980, the SID was constructed upslope (to the north) of Woman Creek to intercept surface runoff from RFETS. A berm was constructed on the downslope side of the SID to contain the water flowing in this ditch. Since construction of the SID in 1980, Woman Creek has not received runoff directly from the southern part of RFETS. Surface-water flow in the SID is intermittent and usually occurs only following precipitation events or snow melt. When flow is low, water tends to pond in several areas of the ditch. The SID begins approximately 200 feet east of the Ash Pits and runs for almost two miles to Pond C-2. It is approximately 4 to 8 feet in depth below and to the west of IHSS 155, with greater depths to the east, toward Pond C-2. It is not lined. Just upslope of Pond C-2, the water flowing in the SID is piped across Woman Creek into Pond C-2. In Pond C-2, the water is sampled, analyzed, and discharged into a canal that diverts water around Great Western Reservoir, according to a National Pollutant Discharge Elimination System (NPDES) agreement (Permit No. CO-0001333).

IHSS 209 and Other Surface Disturbances

Three separate surface disturbances are described in this section: IHSS 209, the Surface Disturbance West of IHSS 209, and the Surface Disturbance South of the Ash Pits. IHSS 209 is located to the southeast of the RFETS industrialized area, south of Woman Creek and approximately 1,000 feet southeast of Pond C-1 (IHSS 142.10). This area was included as an IHSS because unknown activities took place in this area of shallow excavations and surface disturbances. IHSS 209 covers approximately 225,000 feet^2 (5.2 acres) and is located on a long narrow plateau bounded to the north, east and south by a slope leading into the Woman Creek drainage.

A second surface disturbance, the Surface Disturbance West of IHSS 209, located approximately 1,500 feet west of IHSS 209 is also included in the OU 5 investigation. The area consists of several small disturbed areas in a somewhat symmetric arrangement. This disturbance covers an area of approximately 62,500 feet^2 (approximately 1.4 acres).

A third surface disturbance area, the Surface Disturbance South of the Ash Pits, is also being investigated under the OU 5 RFI/RI. This area is located 1,200 feet south of IHSS 133 and south of Woman Creek. This area consists of several former excavation areas. These surface disturbances were identified in aerial photographs taken between 1955 and 1988.

It is not known what activity or activities may have taken place at IHSS 209 or at the other surface disturbances. However, the time period in which these areas were disturbed has been estimated from aerial photographs.

2.1.2 OU 6

Twenty IHSSs geographically located along or within the drainage areas of North and South Walnut Creeks were designated as OU 6 in the IAG (DOE, 1992a). Ten of these IHSSs are detention ponds and include the A-Series and B-Series ponds. The A-Series ponds, located on North Walnut Creek, are Ponds A-1, A-2, A-3, and A-4 (IHSSs 142.1 through 142.4), and the pond identified as Pond A-5, which is referred to as the pond east of the confluence of North and South Walnut Creeks and/or as IHSS 142.12. The B-Series ponds, located on South Walnut Creek, are Ponds B-1, B-2, B-3, B-4, and B-5 (IHSSs 142.5 through 142.9). The remaining ten IHSSs in OU 6 are located on the banks and/or plateau areas which ultimately drain into North or South Walnut Creeks or No Name Gulch. Four of these IHSSs are spray fields and are the North, Pond, South, and East Area Spray Fields (IHSSs 167.1, 167.2, 167.3, and 216.1). Three are Trenches A, B, and C (IHSSs 166.1, 166.2, and 166.3). The remaining three IHSSs are the Sludge Dispersal Area (IHSS 141), the Triangle Area (IHSS 165), and the Old Outfall (IHSS 143). In addition to these twenty IHSSs, IHSS 156.2, the Soil Dump Area also has been added to the Phase I OU 6 investigation, because of its location along the Walnut Creek drainage (DOE, 1992a).

2.2 Nature of Contamination and Previous Investigations

The following paragraphs are very brief summaries of the site contamination and previous investigations of OUs 5 and 6. Documents specific to the individual OU investigations should be referred to when more detailed information is desired.

2.2.1 OU 5

No previous investigations specific to OU 5 are documented in the Phase I RFI/RI Work Plan for OU 5 (DOE, 1992b). IHSS boundaries were modified as a result of findings of the Historical Release Report (HRR) (DOE, 1992) and the aerial photograph investigation associated with the Phase I RFI/RI for OU 5. TM15 presents preliminary Phase I RFI/RI findings (DOE, 1994b). The Hydrologic Data Summary for OU 5, which will be included in the Phase I RFI/RI report has been completed (DOE, 1994d). The Draft Phase I RFI/RI Report for OU 5 is currently being written.

2.2.2 OU 6

Only a few previous limited investigations at OU 6 are mentioned in the Phase I RFI/RI Work Plan for OU 6 (DOE, 1992a). These investigations include sediment sampling in the A- and B-Series ponds, ongoing surface water, groundwater, and sediment sampling programs along Walnut Creek, and the plant-wide Ambient Air Monitoring Program. The Draft Phase I RFI/RI Report for OU 6 is currently being written.

3.0 FIELD PROCEDURES

3.1 Shallow Well-Point Design, Installation, Development, and Sampling

Up to 70 shallow, small-diameter well points will be installed, developed, and sampled at spring and seep locations shown on Figures 2a and 2b. Well Points T4, T5, and T6, and Pumping Well PW114389 are off this map. They are located near the northwest corner of the Industrial Area, on Woman Creek. The specific function and rational of each of these well points is presented on Table 1, below.

Well-point construction will depend on intended use. Generally, the well point will be driven approximately one foot into bedrock. However, if no geologic controls exist in the area to indicate depth to bedrock, well points will be driven until refusal is reached. Well points associated with aquifer testing activities will be designed such that the screened interval will be the same as that of the well being tested. The well points will be installed using a hydraulically-powered hammer apparatus mounted on a small-footprint, all-terrain vehicle in order to minimize surface disturbances and eliminate investigation-derived soil waste material at the well-point sites.

To install a well point, a threaded expendable point is advanced by hydraulically pushing or hammering it to the desired depth. Hand-perforated tubing is then inserted through the drive rods and connected to the point with a threaded stud attached to the end of the tubing. The length of the perforated tubing depends on the magnitude of the anticipated water level fluctuations. The probe rods are then hydraulically withdrawn from the hole. Filter pack material consisting of 10/20 silica sand is then poured directly into the 1-inch diameter annulus to approximately 6 inches above the top of the perforated section while enough tension is applied to the tubing to

TABLE 1
WELL-POINT LOCATION FUNCTION

Well Point I.D.	Seep Invest-gation	Aquifer Testing Prog.	Site-Wide GW Flow Model	Water Balance	OU	Purpose	Location/Rational
S1	X		X		6	GW Sampling, Water Level Measurement	Seep above Pond B-1; determine contaminant contributions to IHSS 142.5.
S2	X		X		6	GW Sampling, Water Level Measurement	Seep above Pond B-1; determine contaminant contributions to IHSS 142.5.
S3	X		X		6	GW Sampling, Water Level Measurement	Seep above Pond B-1; determine contaminant contributions to IHSS 142.5.
S4	X		X		6	GW Sampling	Walnut Creek alluvium below seep; determine contaminant extent near seep.
S5	X		X		6	GW Sampling	Walnut Creek alluvium below seep; determine contaminant extent near seep.
S6	X		X		6	GW Sampling, Water Level Measurement	Seep above South Walnut Creek; determine contaminant contributions to IHSS 142.9.
S7	X		X		6	GW Sampling, Water Level Measurement	Seep above Pond B-5; determine contaminant contributions to IHSS 142.9.
S8	X		X		6	GW Sampling, Water Level Measurement	Seep above Pond B-5; determine contaminant contributions to IHSS 142.9.
S9	X		X		6	GW Sampling, Water Level Measurement	Seep above Pond B-5; determine contaminant contributions to IHSS 142.9.
S10	X		X		6	GW Sampling	Walnut Creek alluvium below seep; determine contaminant extent near seep.
S11	X		X		5	GW Sampling	Seep below Pond C1; determine contaminant contributions to Woman Creek.
T1		X			None	Observation well for pumping well 10894.	Walnut Creek alluvium below tributary confluences; determine hydraulic conductivity per OP GW.08.
T2		X			None	Observation well for pumping well 10894.	Walnut Creek alluvium below tributary confluences; determine hydraulic conductivity per OP GW.08.
T3		X			None	Observation well for pumping well 10894.	Walnut Creek alluvium below tributary confluences; determine hydraulic conductivity per OP GW.08.
T4		X			Ind. Area	Observation well for pumping well P114389	North Walnut Creek alluvium above industrial area; determine hydraulic conductivity per OP GW.08.
T5		X			Ind. Area	Observation well for pumping well P114389	North Walnut Creek alluvium above industrial area; determine hydraulic conductivity per OP GW.08.

TABLE 1
WELL-POINT LOCATION FUNCTION, Continued.

Well Point I.D.	Seep Invest-gation	Aquifer Testing Prog.	Site-Wide GW Flow Model	Water Balance	OU	Purpose	Location/Rational
T6		X			Ind. Area	Observation well for pumping well P114389	North Walnut Creek alluvium above industrial area; Determine hydraulic conductivity per OP GW.08
T7		X			6	Observation well for pumping well 10694	North Walnut Creek alluvium below Pond A-3; Determine hydraulic conductivity per OP GW.08
T8		X			6	Observation well for pumping well 10694	North Walnut Creek alluvium below Pond A-3; Determine hydraulic conductivity per OP GW.08
T9		X			6	Observation well for pumping well 10694	North Walnut Creek alluvium below Pond A-3; Determine hydraulic conductivity per OP GW.08
T10		X			7	Observation well for pumping well 12094	No Name Gulch alluvium; Determine hydraulic conductivity per OP GW.08
T11		X			7	Observation well for pumping well 12094	No Name Gulch alluvium; Determine hydraulic conductivity per OP GW.08
T12		X			7	Observation well for pumping well 12094	No Name Gulch alluvium; Determine hydraulic conductivity per OP GW.08
T13		X			None	Observation well for pumping well 41691	Walnut Creek alluvium at east boundary; Determine hydraulic conductivity per OP GW.08
T14		X			None	Observation well for pumping well 41691	Walnut Creek alluvium at east boundary; Determine hydraulic conductivity per OP GW.08
T15		X			None	Observation well for pumping well 41691	Walnut Creek alluvium at east boundary; Determine hydraulic conductivity per OP GW.08
T16		X			6	Observation well for pumping well 41091	North Walnut Creek alluvium below Pond A-4; Determine hydraulic conductivity per OP GW.08
T17		X			6	Observation well for pumping well 41091	North Walnut Creek alluvium below Pond A-4; Determine hydraulic conductivity per OP GW.08
T18		X			6	Observation well for pumping well 41091	North Walnut Creek alluvium below Pond A-4; Determine hydraulic conductivity per OP GW.08
T19		X			6	Observation well for pumping well 3886	South Walnut Creek alluvium below Pond B-5; Determine hydraulic conductivity per OP GW.08
T20		X			6	Observation well for pumping well 3886	South Walnut Creek alluvium below Pond B-5; Determine hydraulic conductivity per OP GW.08
T21		X			4	Observation well for pumping well 1586	North Walnut Creek alluvium above A-Series ponds; Determine hydraulic conductivity per OP GW.08

TABLE 1
WELL-POINT LOCATION FUNCTION, Continued.

Well Point I.D.	Seep Invest-gation	Aquifer Testing Prog.	Site-Wide GW Flow Model	Water Balance	OU	Purpose	Location/Rational
T22		X			4	Observation well for pumping well 1586	North Walnut Creek alluvium above A-Series ponds; Determine hydraulic conductivity per OP GW.08
T23		X			None	Observation well for pumping well 10394	Woman Creek alluvium at east boundary; Determine hydraulic conductivity per OP GW.08
T24		X			None	Observation well for pumping well 10394	Woman Creek alluvium at east boundary; Determine hydraulic conductivity per OP GW.08
T25		X			None	Observation well for pumping well 10394	Woman Creek alluvium at east boundary; Determine hydraulic conductivity per OP GW.08
W1			X		None	Potentiometric Surface Control	Woman Creek alluvium; Improve coverage for gw flow model
W2			X		None	Potentiometric Surface Control	Woman Creek alluvium; Improve coverage for gw flow model
W3			X		None	Potentiometric Surface Control	Woman Creek alluvium; Improve coverage for gw flow model
W4			X		None	Potentiometric Surface Control	Woman Creek colluvium; Improve coverage for gw flow model
W5			X		None	Potentiometric Surface Control	Woman Creek colluvium; Improve coverage for gw flow model
W6			X	X	None	Potentiometric Surface Control	East boundary tributary; Improve coverage for gw flow model/estimate aquifer extent
W7			X		None	Potentiometric Surface Control	East boundary tributary; Improve coverage for gw flow model
W8			X		None	Potentiometric Surface Control	Walnut Creek colluvium; Improve coverage for gw flow model
W9			X		None	Potentiometric Surface Control	Walnut Creek colluvium; Improve coverage for gw flow model
W10			X		None	Potentiometric Surface Control	Walnut Creek colluvium; Improve coverage for gw flow model
W11			X		None	Potentiometric Surface Control	Walnut Creek alluvium; Improve coverage for gw flow model
W12			X		None	Potentiometric Surface Control	Walnut Creek alluvial tributary; Improve coverage for gw flow model
W13			X		None	Potentiometric Surface Control	Walnut Creek alluvial tributary; Improve coverage for gw flow model

TABLE 1
WELL-POINT LOCATION FUNCTION, Continued.

Well Point I.D.	Seep Invest-gation	Aquifer Testing Prog.	Site-Wide GW Flow Model	Water Balance	OU	Purpose	Location/Rational
W14			X		None	Potentiometric Surface Control	Walnut Creek alluvial tributary; Improve coverage for gw flow model
W15			X		None	Potentiometric Surface Control	No Name Gulch alluvium; Improve coverage for gw flow model
W16			X		None	Potentiometric Surface Control	No Name Gulch alluvium; Improve coverage for gw flow model
W17			X		None	Determine saturated thickness	East boundary; Estimate aquifer extent
W18			X		None	Potentiometric Surface Control	Walnut Creek colluvium: Improve coverage for gw flow model
W19			X		6	Potentiometric Surface Control	North Walnut Creek alluvium between Ponds A-2 and A-3; Improve coverage for gw flow model
W20			X		None	Potentiometric Surface Control	East boundary tributary; Improve coverage for gw flow model
W21			X		6	Potentiometric Surface Control	North Walnut Creek alluvium between Ponds A-3 and A-4; Improve coverage for gw flow model
W22			X		6	Potentiometric Surface Control	South Walnut Creek alluvium below Pond B-5; Improve coverage for gw flow model
W23			X		6	Potentiometric Surface Control	South Walnut Creek alluvium between Ponds B-4 and B-5; Improve coverage for gw flow model
W24			X		6	Potentiometric Surface Control	South Walnut Creek alluvium between Ponds B-3 and B-4; Improve coverage for gw flow model
W25				X	None	Determine saturated thickness	East boundary; Estimate aquifer extent
W26				X	None	Determine saturated thickness	East boundary; Estimate aquifer extent
W27				X	None	Determine saturated thickness	East boundary; Estimate aquifer extent
W28				X	None	Determine saturated thickness	East boundary; Estimate aquifer extent
W29				X	None	Determine saturated thickness	East boundary; Estimate aquifer extent
W30				X	None	Determine saturated thickness	East boundary; Estimate aquifer extent

TABLE 1
WELL-POINT LOCATION FUNCTION, Continued.

Well Point I.D.	Seep Invest-gation	Aquifer Testing Prog.	Site-Wide GW Flow Model	Water Balance	OU	Purpose	Location/Rational
W31				X	None	Determine saturated thickness	East boundary; Estimate aquifer extent
W32				X	None	Determine saturated thickness	East boundary; Estimate aquifer extent
W33				X	None	Determine saturated thickness	East boundary; Estimate aquifer extent
W34				X	None	Determine saturated thickness	East boundary; Estimate aquifer extent

keep it straight and vertical. Because of the difficulty in measuring the top of the sand pack in such a small annulus, it may be necessary to add sand to within a foot of ground surface. That is, the point at which the sand is visible from the surface. The remaining annulus is then backfilled with granular bentonite to a thickness of at least 6 inches to create a seal above the filter pack.

Each well point will be constructed of inert materials in a manner that is consistent with OP GT.06 (DOE, 1992f). Specifically, well points will be constructed with stainless steel tips (including threaded connector) and Teflon tubing. Tubing will be approximately 3/8-inch outside diameter except for those well points associated with aquifer testing activities and those requiring larger diameter tubing for sampling because of potentially slow recharge. These well points will require 3/4-inch outside diameter tubing to allow the placement of pressure transducers and larger casing volumes, respectively. The bottom five feet of tubing will be perforated by hand with 1/16-inch diameter holes.

The well points will be completed at the surface with a 10-inch minimum diameter concrete pad that is at least 3 inches thick. The concrete pad will be anchored to the soil by two 18-inch pieces of #3 reinforcing bar (rebar) driven approximately 15 inches into the soil. The top of the tubing will be enclosed within a 6-inch long piece of 1-inch diameter poly-vinyl chloride (PVC) protective casing with a threaded cap. Either screws or holes will be required to keep the protective casing secure in the concrete. The PVC casing will extend 3 inches above the concrete and be vertical. The well-point number will be inscribed in the concrete. A 4-foot long steel fence post will be driven 18 inches into the soil approximately 2 feet from the well point. A well-point designation marker will be mounted to the fence post. Abandoned well-point borings will be sealed with bentonite prior to departure from the site.

Well points will be surveyed to 0.01-foot vertical accuracy using the top of the protective casing as the reference point because of the flexibility of the well-point tubing. All locations will be cleared and free of subsurface utilities.

Core samples will be collected only from the 12 well points located along the eastern boundary of the buffer zone. These well points are designated as W6, W17, and W25 through W34 (see Table 1 and Figures 2a and 2b). The core samples will be collected at the suspected bedrock contact to confirm top-of-bedrock.

Each well point will be developed using a peristaltic pump to remove water from the completed well point in accordance with OP GW.02 (DOE, 1992f). A well-point development procedure to accommodate the smaller casing volumes will be written and submitted for approval should a modified procedure be necessary. Upon review and approval of this procedure, the RFETS technical representative will prepare a Document Modification Request (DMR) for OP GW.02 based on the procedure. It is anticipated that up to three attempts will be made to develop the well points. If the development criteria in OP GW.02 cannot be achieved, well development will be considered complete after the third attempt and the well point will be sampled. Water will not be introduced into the well point to facilitate development.

Water levels in the 3/4-inch diameter well points will be measured in accordance with OP GW.01 (DOE, 1992f) with an electronic water level sounder. Water levels in the smaller-diameter well points will be measured with a manometer because an electronic water level sounder will not fit into the 3/16-inch inside diameter of the well point. To measure water levels with a manometer, a length of Teflon tubing is attached to the manometer and inserted into the well-point tubing while watching the manometer. As soon as a change in reading is observed, a point is marked on the inserted tube. The tubing is then withdrawn and the length from the downhole end of the tubing to the marked point is measured. A total of three measurements will be taken by this method by two different individuals with one team member taking the first and third readings and the other team member taking the second reading. As stipulated in GW.1 for electric water level sounders, if the three measurements do not agree within 0.05 foot, additional measurements will be taken until three consecutive readings are shown to agree within 0.05 foot. An average of the reproducible readings will be utilized for the determination of the water level.

Water samples will be collected in accordance with OP GW.6, Groundwater Sampling (DOE, 1992f). A peristaltic pump will be used to collect samples with the exception of those to be tested for volatile organics (VOCs). VOC samples will be collected as described in OP GT.6 but with a modified bailing method. This method involves inserting a length of Teflon tubing into the well-point tubing to the bottom of the well point. The sample team member seals the end of the tubing with a gloved finger and withdraws the tubing containing the groundwater sample. The other end of the tubing is placed near the mouth of the VOC vial. When the sampler removes the finger sealing the tubing, the sample empties into the vial.

3.2 Stream Gain/Loss Monitoring

This subtask will involve monthly measurements of stream-flow discharges through August 1995 at selected locations within the RFETS property boundaries in Woman and Rock Creeks (Figure 3). The specific function and rational of each of these monitoring locations is presented on Table 2 below. Twenty-eight measurement sites were established on Woman Creek for the Woman Creek Gain/Loss Study between the RFETS West Boundary and Indiana Street (Fedors and Warner, 1993) as shown on Figure 3. These 28 Woman Creek locations have been monitored approximately monthly from October 1991 to March 1994. Measurements of discharge in Woman Creek at most of the 28 existing sites will be resumed as part of this Seepage Characterization. In addition, 15 new monitoring locations will be added to the network in Woman Creek. These measurement points were added to increase resolution and to aid in the determination of evaporitic water contributions from Rocky Flats Lake.

A new network of 39 gain/loss measurement points will be established in Rock Creek between approximately the west RFETS boundary and State Highway 128 (Figure 3). Locations of measurement points have been selected for this new network so that meaningful gain/loss estimates may be made. After establishment of the measurement networks, monthly discharge measurements will be taken. Details on the measurement technique, based upon those used in Woman Creek, are presented below.

TABLE 2
STREAM/SPRING-FLOW GAUGING LOCATION FUNCTION

Monitoring Station Number	Drainage	Purpose	Location/Rationale
STIE1	Woman Creek	Stream Flow Measurement; Isotope sampling	600 feet downstream of west boundary on main creek. Determine surface/groundwater interactions of main creek for OU 5 modeling; calibration of new locations. Determine presence and amount of evaporitic water contributions to stream flow.
STIE2	Woman Creek	Stream Flow Measurement; Isotope sampling	1020 feet downstream of west boundary on main creek. Determine surface/groundwater interactions of main creek for OU 5 modeling; calibration of new locations. Determine presence and amount of evaporitic water contributions to stream flow.
STIE3	Woman Creek	Stream Flow Measurement; Isotope sampling	1600 feet downstream of west boundary on main creek. Determine surface/groundwater interactions of main creek for OU 5 modeling; calibration of new locations. Determine presence and amount of evaporitic water contributions to stream flow.
STIE4	Woman Creek	Stream Flow Measurement; Isotope sampling	1950 feet downstream of west boundary on main creek. Determine surface/groundwater interactions of main creek for OU 5 modeling; calibration of new locations. Determine presence and amount of evaporitic water contributions to stream flow.
STIE5	Woman Creek	Stream Flow Measurement; Isotope sampling	2200 feet downstream of west boundary on tributary creek. Determine surface/groundwater interactions of tributary creek for OU 5 modeling; calibration of new locations. Determine presence and amount of evaporitic water contributions to stream flow.
STIE6	Woman Creek	Stream Flow Measurement; Isotope sampling	1700 feet downstream of west boundary on tributary creek. Determine surface/groundwater interactions of tributary creek for OU 5 modeling; calibration of new locations. Determine presence and amount of evaporitic water contributions to stream flow.
STIE7	Woman Creek	Stream Flow Measurement; Isotope sampling	750 feet downstream of west boundary on tributary creek. Determine surface/groundwater interactions of tributary creek for OU 5 modeling; calibration of new locations. Determine presence and amount of evaporitic water contributions to stream flow.
STIE8	Woman Creek	Stream Flow Measurement; Isotope sampling	2625 feet downstream of west boundary on main creek. Determine surface/groundwater interactions of main creek for OU 5 modeling; calibration of new locations. Determine presence and amount of evaporitic water contributions to stream flow.
STIE9	Woman Creek	Stream Flow Measurement; Isotope sampling	3900 feet downstream of west boundary on main creek. Determine surface/groundwater interactions of main creek for OU 5 modeling; calibration of new locations. Determine presence and amount of evaporitic water contributions to stream flow.
STIE10	Woman Creek	Stream Flow Measurement; Isotope sampling	4425 feet downstream of west boundary on main creek. Determine surface/groundwater interactions of main creek for OU 5 modeling; calibration of new locations. Determine presence and amount of evaporitic water contributions to stream flow.

Key:
- STIE Stream location from original Woman Creek Gain/Loss Study
- ST New stream gauging location.
- SP New spring gauging location.

TABLE 2
STREAM/SPRING-FLOW GAUGING LOCATION FUNCTION, Continued.

Monitoring Station Number	Drainage	Purpose	Location/Rationale
STIE11	Woman Creek	Stream Flow Measurement; Isotope sampling	5025 feet downstream of west boundary on main creek. Determine surface/groundwater interactions of main creek for OU 5 modeling; calibration of new locations. Determine presence and amount of evaporitic water contributions to stream flow.
STIE12	Woman Creek	Stream Flow Measurement; Isotope sampling.	5775 feet downstream of west boundary on main creek. Determine surface/groundwater interactions of main creek for OU 5 modeling. Calibration of new locations. Determine presence and amount of evaporitic water contributions to stream flow.
STIE13	Woman Creek	Stream Flow Measurement; Isotope sampling.	200 feet upstream of Woman Creek confluence on Antelope Springs tributary. Determine surface/groundwater interactions of tributary creek for OU 5 modeling; calibration of new locations. Determine presence and amount of evaporitic water contributions to stream flow.
STIE14	Woman Creek	Stream Flow Measurement; Isotope sampling.	2375 feet downstream of Antelope Springs on tributary creek. Determine surface/groundwater interactions of tributary creek for OU 5 modeling; calibration of new locations. Determine presence and amount of evaporitic water contributions to stream flow.
STIE15	No station	No station	No station.
STIE16	Woman Creek	Stream Flow Measurement; Isotope sampling	600 feet downstream of confluence with Antelope Springs tributary on main creek. Determine surface/groundwater interactions of main creek for OU 5 modeling; calibration of new locations. Determine presence and amount of evaporitic water contributions to stream low.
STIE17	Woman Creek	Stream Flow Measurement; Isotope sampling	1450 feet downstream of confluence with Antelope Springs tributary on main creek. Determine surface/groundwater interactions of main creek for OU 5 modeling; calibration of new locations. Determine presence and amount of evaporitic water contributions to stream flow.
C1	Woman Creek	Stream Flow Measurement; Isotope sampling	100 feet downstream of Pond C-1 dam on main creek. Determine surface/groundwater interactions of main creek for OU 5 modeling; calibration of new locations. Determine presence and amount of evaporitic water contributions to stream flow.
STIE18	Woman Creek	Stream Flow Measurement; Isotope sampling	500 feet downstream of Pond C-1 dam on main creek. Determine surface/groundwater interactions of main creek for OU 5 modeling; calibration of new locations. Determine presence and amount of evaporitic water contributions to stream flow.
STIE19	Woman Creek	Stream Flow Measurement; Isotope sampling	850 feet downstream of Pond C-1 dam on main creek. Determine surface/groundwater interactions of main creek for OU 5 modeling; calibration of new locations. Determine presence and amount of evaporitic water contributions to stream flow.

Key:
STIE Stream location from original Woman Creek Gain/Loss Study
ST New stream gauging location.
SP New spring gauging location.

TABLE 2
STREAM/SPRING-FLOW GAUGING LOCATION FUNCTION, Continued.

Monitoring Station Number	Drainage	Purpose	Location/Rationale
STIE20	Woman Creek	Stream Flow Measurement; Isotope sampling	1425 feet downstream of Pond C-1 dam on main creek. Determine surface/groundwater interactions of main creek for OU 5 modeling; calibration of new locations. Determine presence and amount of evaporitic water contributions to stream flow.
STIE21	Woman Creek	Stream Flow Measurement; Isotope sampling	750 feet downstream of Pond C-2 dam on main creek. Determine surface/groundwater interactions of main creek for OU 5 modeling; calibration of new locations. Determine presence and amount of evaporitic water contributions to stream flow.
ST22	Woman Creek	Stream Flow Measurement; Isotope Sampling	75 feet upstream of S. Boulder Diversion Canal on tributary. Determine surface/groundwater interactions of tributary creek for OU 5 modeling; determine flow rate upstream of canal for estimating canal seepage loss. Determine presence of canal water contributions to stream flow using isotopes; establish isotope background.
ST23	Woman Creek	Stream Flow Measurement; Isotope Sampling	75 feet upstream of S. Boulder Diversion Canal on Kinnear Ditch. Determine surface/groundwater interactions of tributary creek for OU 5 modeling. Determine flow rate upstream of canal for estimating canal seepage loss. Determine presence of canal water contributions to stream flow using isotopes; establish isotope background.
ST24	Woman Creek	Stream Flow Measurement; Isotope Sampling	1025 feet downstream of S. Boulder Diversion Canal on tributary. Determine surface/groundwater interactions of tributary creek for OU 5 modeling. Determine flow rate downstream of canal for estimating canal seepage loss. Determine presence of canal water contributions to stream flow using isotopes; establish isotope background.
ST25	Woman Creek	Stream Flow Measurement; Isotope Sampling	1350 feet downstream of S. Boulder Diversion Canal on Kinnear Ditch. Determine surface/groundwater interactions of tributary creek for OU 5 modeling. Determine flow rate downstream of canal for estimating canal seepage loss. Determine presence of canal water contributions to stream flow using isotopes; establish isotope background.
ST26	Woman Creek	Stream Flow Measurement; Isotope Sampling	2375 feet upstream of west boundary on main creek. Determine surface/groundwater interactions of main creek for OU 5 modeling. Determine flow rate at Laramie/Fox Hills SS outcrop for estimating stream gain/loss. Determine presence of canal water contributions to stream flow using isotopes; establish isotope background.
ST27	Woman Creek	Stream Flow Measurement; Isotope Sampling	700 feet upstream of west boundary on main creek. Determine surface/groundwater interactions of main creek for OU 5 modeling. Determine flow rate downstream of Laramie/Fox Hills SS outcrop for estimating stream gain/loss. Determine presence and amount of evaporitic water contributions to stream flow.
ST28	Woman Creek	Stream Flow Measurement; Isotope Sampling	At west boundary on main creek. Determine surface/groundwater interactions of main creek for OU 5 modeling. Determine flow rate at west boundary for estimating stream gain/loss in main creek. Determine presence and amount of evaporitic water contributions to stream flow

Key:
STIE Stream location from original Woman Creek Gain/Loss Study
ST New stream gauging location.
SP New spring gauging location.

TABLE 2
STREAM/SPRING-FLOW GAUGING LOCATION FUNCTION, Continued.

Monitoring Station Number	Drainage	Purpose	Location/Rationale
ST29	Woman Creek	Stream Flow Measurement; Isotope Sampling	At west boundary on main creek. Determine surface/groundwater interactions of main creek for OU 5 modeling. Determine flow rate at west boundary for estimating stream gain/loss in main creek. Determine presence and amount of evaporitic water contributions to stream flow.
ST30	Woman Creek	Stream Flow Measurement; Isotope Sampling	1275 feet upstream of west boundary on tributary creek. Determine surface/groundwater interactions of tributary creek for OU 5 modeling. Determine flow rate of Smart 2 Ditch upstream of west boundary for estimating gain/loss. Determine presence and amount of evaporitic water contributions to stream flow.
ST31	Woman Creek	Stream Flow Measurement; Isotope Sampling	75 feet downstream of small tributary confluence on Antelope Springs tributary. Determine surface/groundwater interactions of tributary creek for OU 5 modeling. Determine stream gain/losses along Antelope Springs tributary. Determine presence and amount of evaporitic water contributions to stream flow.
ST32	Woman Creek	Stream Flow Measurement; Isotope Sampling	75 feet upstream of small tributary confluence on tributary. Determine surface/groundwater interactions of tributary creek for OU 5 modeling. Determine flow rate contributions to Antelope Springs tributary. Determine presence and amount of evaporitic water contributions to stream flow.
ST33	Woman Creek	Stream Flow Measurement; Isotope Sampling	500 feet downstream of Orchard Spring tributary on main creek. Determine surface/groundwater interactions of main creek for OU 5 modeling. Improve gain/loss resolution between locations STIE8 and STIE9 on main creek. Determine presence and amount of evaporitic water contributions to stream flow.
ST34	Woman Creek	Stream Flow Measurement; Isotope Sampling	350 feet downstream of STIE11 on main creek. Determine surface/groundwater interactions of main creek for OU 5 modeling. Improve gain/loss resolution between locations STIE11 and STIE12. Determine presence and amount of evaporitic water contributions to stream flow.
ST35	Woman Creek	Stream Flow Measurement; Isotope Sampling	350 feet downstream of location STIE17 on main creek. Determine surface/groundwater interactions of main creek for OU 5 modeling. Determine flow rate contribution to Pond C-1. Determine presence and amount of evaporitic water contributions to stream flow.
ST36	Rock Creek	Stream Flow Measurement; Isotope Sampling	2650 feet upstream of tributary confluence on tributary. Determine surface/groundwater interactions of tributary creek for baseline characterization. Determine flow rate for estimating stream gain/loss in tributary creek. Determine presence of evaporitic water contributions to stream flow from mining operations.
ST37	Rock Creek	Stream Flow Measurement; Isotope Sampling	At west boundary on main creek. Determine surface/groundwater interactions of main creek for baseline characterization. Determine flow rate upstream of Laramie/Fox Hills SS subcrop for estimating stream gain/loss. Establish environmental isotope background.

Key:
STIE Stream location from original Woman Creek Gain/Loss Study
ST New stream gauging location.
SP New spring gauging location.

TABLE 2
STREAM/SPRING-FLOW GAUGING LOCATION FUNCTION, Continued.

Monitoring Station Number	Drainage	Purpose	Location/Rationale
ST38	Rock Creek	Stream Flow Measurement; Isotope Sampling	1525 feet downstream of west boundary on main creek. Determine surface/groundwater interactions of main creek for baseline characterization. Determine flow rate at Laramie/Fox Hills SS subcrop for estimating stream gain/loss. Establish environmental isotope background.
ST39	Rock Creek	Stream Flow Measurement; Isotope Sampling	3225 feet downstream of west boundary on main creek. Determine surface/groundwater interactions of main creek for baseline characterization. Determine flow rate downstream of Laramie/Fox Hills SS subcrop for estimating stream gain/loss. Establish environmental isotope background.
ST40	Rock Creek	Stream Flow Measurement; Isotope sampling	75 feet upstream of small tributary confluence on tributary. Determine flow rate contributions to main creek. Establish environmental isotope background.
ST41	Rock Creek	Stream Flow Measurement; Isotope Sampling	4075 feet downstream of west boundary on main creek. Determine surface/groundwater interactions of main creek for baseline characterization. Determine flow rate downstream of small pond for estimating stream gain/loss in main creek. Establish environmental isotope background.
ST42	Rock Creek	Stream Flow Measurement; Isotope Sampling	4500 feet downstream of west boundary on main creek; Determine surface/groundwater interactions of main creek for baseline characterization; Determine flow rate for estimating stream gain/loss in main creek Establish environmental isotope background.
ST43	Rock Creek	Stream Flow Measurement; Isotope Sampling	5600 feet downstream of west boundary on main creek; Determine surface/groundwater interactions of main creek for baseline characterization; Determine flow rate for estimating stream gain/loss in main creek Establish environmental isotope background.
ST44	Rock Creek	Stream Flow Measurement; Isotope Sampling	6975 feet downstream of west boundary on main creek upstream of Lindsey ranch pond; Determine surface/groundwater interactions of main creek for baseline characterization; Determine flow rate for estimating stream gain/loss in main creek Establish environmental isotope background.
ST45	Rock Creek	Stream Flow Measurement; Isotope Sampling	75 feet downstream of Lindsey ranch pond dam on main creek; Determine surface/groundwater interactions of main creek for baseline characterization; Determine flow rate for estimating stream gain/loss in main creek Establish environmental isotope background.
ST46	Rock Creek	Stream Flow Measurement; Isotope sampling	75 feet upstream of small tributary confluence on tributary; Determine flow rate contributions to main creek Establish environmental isotope background.

Key:
STIE Stream location from original Woman Creek Gain/Loss Study
ST New stream gauging location.
SP New spring gauging location.

TABLE 2
STREAM/SPRING-FLOW GAUGING LOCATION FUNCTION, Continued.

Monitoring Station Number	Drainage	Purpose	Location/Rationale
ST47	Rock Creek	Stream Flow Measurement; Isotope Sampling	1275 feet downstream of Lindsey ranch pond dam on main creek. Determine surface/groundwater interactions of main creek for baseline characterization. Determine flow rate for estimating stream gain/loss in main creek. Establish environmental isotope background.
ST48	Rock Creek	Stream Flow Measurement; Isotope Sampling	2450 feet downstream of Lindsey ranch pond dam on main creek. Determine surface/groundwater interactions of main creek for baseline characterization. Determine flow rate for estimating stream gain/loss in main creek upstream of major tributary. Establish environmental isotope background.
ST49	Rock Creek	Stream Flow Measurement; Isotope Sampling	3575 feet downstream of Lindsey ranch pond dam on main creek. Determine surface/groundwater interactions of main creek for baseline characterization. Determine flow rate for estimating stream gain/loss in main creek upstream of major tributary. Establish environmental isotope background.
ST50	Rock Creek	Stream Flow Measurement; Isotope Sampling	4500 feet downstream of Lindsey ranch pond dam on main creek. Determine surface/groundwater interactions of main creek for baseline characterization. Determine flow rate for estimating stream gain/loss in main creek upstream of tributaries. Establish environmental isotope background.
ST51	Rock Creek	Stream Flow Measurement; Isotope sampling.	75 feet upstream of tributary confluence on tributary. Determine flow rate contributions to main creek. Establish environmental isotope background.
ST52	Rock Creek	Stream Flow Measurement; Isotope Sampling	5700 feet downstream of Lindsey ranch pond dam on main creek. Determine surface/groundwater interactions of main creek for baseline characterization. Determine flow rate for estimating stream gain/loss in main creek upstream of small tributary. Establish environmental isotope background.
ST53	Rock Creek	Stream Flow Measurement; Isotope sampling.	75 feet upstream of tributary confluence on tributary. Determine flow rate contributions to main creek. Establish environmental isotope background.
ST54	Rock Creek	Stream Flow Measurement; Isotope Sampling	At north boundary on main creek. Determine surface/groundwater interactions of main creek for baseline characterization. Determine flow rate for estimating stream gain/loss in main creek. Establish environmental isotope background.
ST55	Rock Creek	Stream Flow Measurement; Isotope sampling	75 feet upstream of tributary confluence on tributary. Determine surface/groundwater interactions of tributary creek for baseline characterization. Determine flow rate contributions to main creek. Determine presence of evaporitic water contributions to stream flow from mining operations.

Key:
- STIE Stream location from original Woman Creek Gain/Loss Study
- ST New stream gauging location.
- SP New spring gauging location.

TABLE 2
STREAM/SPRING-FLOW GAUGING LOCATION FUNCTION, Continued.

Monitoring Station Number	Drainage	Purpose	Location/Rationale
ST56	Rock Creek	Stream Flow Measurement; Isotope sampling	75 feet upstream of tributary confluence on tributary. Determine surface/groundwater interactions of tributary creek for baseline characterization. Determine flow rate contributions to main creek. Determine presence of evaporitic water contributions to stream flow from mining operations.
ST57	Rock Creek	Stream Flow Measurement; Isotope sampling	75 feet upstream of tributary confluence on tributary. Determine surface/groundwater interactions of tributary creek for baseline characterization. Determine flow rate for estimating stream gain/loss in tributary creek. Determine presence of evaporitic water contributions to stream flow from mining operations.
ST58	Rock Creek	Stream Flow Measurement; Isotope sampling	75 feet upstream of tributary confluence on tributary. Determine surface/groundwater interactions of tributary creek for baseline characterization. Determine flow rate contributions to tributary creek. Establish environmental isotope background.
ST59	Rock Creek	Stream Flow Measurement; Isotope sampling	1775 feet upstream of tributary confluence on tributary. Determine surface/groundwater interactions of tributary creek for baseline characterization. Determine flow rate for estimating stream gain/loss in tributary creek. Establish environmental isotope background.
ST60	Rock Creek	Stream Flow Measurement; Isotope sampling	3900 feet upstream of tributary confluence on tributary. Determine surface/groundwater interactions of tributary creek for baseline characterization. Determine flow rate for estimating stream gain/loss in tributary creek. Establish environmental isotope background.
ST61	Rock Creek	Stream Flow Measurement; Isotope sampling	5175 feet upstream of tributary confluence on tributary. Determine surface/groundwater interactions of tributary creek for baseline characterization. Determine flow rate for estimating stream gain/loss in tributary creek. Establish environmental isotope background.
ST62	Rock Creek	Stream Flow Measurement; Isotope sampling	75 feet upstream of tributary confluence on tributary. Determine surface/groundwater interactions of tributary creek for baseline characterization. Determine flow rate contributions to tributary creek. Determine presence of evaporitic water contributions to stream flow from mining operations.
ST63	Rock Creek	Stream Flow Measurement; Isotope sampling	1450 feet upstream of tributary confluence on tributary. Determine surface/groundwater interactions of tributary creek for baseline characterization. Determine flow rate for estimating stream gain/loss in tributary creek. Determine presence of evaporitic water contributions to stream flow from mining operations.
ST64	Rock Creek	Stream Flow Measurement; Isotope sampling	2800 feet upstream of tributary confluence on tributary. Determine surface/groundwater interactions of tributary creek for baseline characterization. Determine flow rate for estimating stream gain/loss in tributary creek. Determine presence of evaporitic water contributions to stream flow from mining operations.

Key:
STIE Stream location from original Woman Creek Gain/Loss Study
ST New stream gauging location.
SP New spring gauging location.

TABLE 2
STREAM/SPRING-FLOW GAUGING LOCATION FUNCTION, Continued.

Monitoring Station Number	Drainage	Purpose	Location/Rationale
ST65	Rock Creek	Stream Flow Measurement; Isotope sampling	3825 feet upstream of tributary confluence on tributary. Determine surface/groundwater interactions of tributary creek for baseline characterization. Determine flow rate downstream of Laramie/Fox Hills SS subcrop for estimating stream gain/loss. Establish environmental isotope background.
ST66	Rock Creek	Stream Flow Measurement; Isotope sampling	At Laramie/Fox Hills subcrop on tributary creek. Determine surface/groundwater interactions of tributary creek for baseline characterization. Determine flow rate at Laramie/Fox Hills SS subcrop for estimating stream gain/loss. Establish environmental isotope background.
ST67	Rock Creek	Stream Flow Measurement; Isotope sampling	At west boundary on tributary. Determine surface/groundwater interactions of tributary creek for baseline characterization. Determine flow rate upstream of Laramie/Fox Hills SS subcrop for estimating stream gain/loss. Establish environmental isotope background.
ST68	Rock Creek	Stream Flow Measurement; Isotope sampling	75 feet upstream of tributary confluence on tributary. Determine surface/groundwater interactions of tributary creek for baseline characterization. Determine flow rate contributions at tributary mouth. Determine presence of evaporitic water contributions to stream flow from mining operations.
ST69	Rock Creek	Stream Flow Measurement; Isotope sampling	1950 feet upstream of tributary confluence on tributary. Determine surface/groundwater interactions of tributary creek for baseline characterization. Determine flow rate for estimating stream gain/loss in tributary creek. Determine presence of evaporitic water contributions to stream flow from mining operations.
ST70	Rock Creek	Stream Flow Measurement; Isotope sampling	75 feet upstream of tributary confluence on small tributary. Determine flow rate contributions to tributary creek. Determine presence of evaporitic water contributions to stream flow from mining operations.
ST71	Rock Creek	Stream Flow Measurement; Isotope sampling	75 feet upstream of small tributary confluence on main tributary. Determine surface/groundwater interactions of tributary creek for baseline characterization. Determine flow rate for estimating stream gain/loss in tributary creek. Determine presence of evaporitic water contributions to stream flow from mining operations.
ST72	Rock Creek	Stream Flow Measurement; Isotope sampling	75 feet upstream of tributary confluence on small tributary; Determine flow rate contributions to tributary creek Determine presence of evaporitic water contributions to stream flow from mining operations
ST73	Rock Creek	Stream Flow Measurement; Isotope sampling	75 feet upstream of small tributary confluence on main tributary. Determine surface/groundwater interactions of tributary creek for baseline characterization. Determine flow rate for estimating stream gain/loss in tributary creek. Determine presence of evaporitic water contributions to stream flow from mining operations.

Key:
- STIE — Stream location from original Woman Creek Gain/Loss Study
- ST — New stream gauging location.
- SP — New spring gauging location.

TABLE 2
STREAM/SPRING-FLOW GAUGING LOCATION FUNCTION, Continued.

Monitoring Station Number	Drainage	Purpose	Location/Rationale
ST74	Rock Creek	Stream Flow Measurement; Isotope sampling	1600 feet upstream of small tributary confluence on main tributary. Determine surface/groundwater interactions of tributary creek for baseline characterization. Determine flow rate for estimating stream gain/loss in tributary creek. Determine presence of evaporitic water contributions to stream flow from mining operations.
SP1	Woman Creek	Spring Flow Measurement; Water quality sampling; Isotope sampling	Orchard Spring area, west seepage. Determine hydrologic conditions in support of seep aquatic biota monitoring. Determine flow rate for estimating stream gain/loss in main creek. Determine presence and amount of evaporitic water contributions to stream flow.
SP2	Woman Creek	Spring Flow Measurement; Water quality sampling; Isotope sampling	Seep associated with old Woman Creek channel. Determine hydrologic conditions in support of seep aquatic biota monitoring. Determine flow rate for estimating stream gain/loss in main creek. Determine presence and amount of evaporitic water contributions to stream flow.
SP3	Woman Creek	Spring Flow Measurement; Water quality sampling; Isotope sampling	Orchard Spring area, east seepage. Determine hydrologic conditions in support of seep aquatic biota monitoring. Determine flow rate for estimating stream gain/loss in main creek. Determine presence and amount of evaporitic water contributions to stream flow .
SP4	Woman Creek	Spring Flow Measurement; Water quality sampling; Isotope sampling	Seep below east end of OU1 French Drain. Determine hydrologic conditions in support of seep aquatic biota monitoring. Determine flow rate for estimating stream gain/loss in main creek. Determine source of seep using isotopes.
SP5	Walnut Creek	Spring Flow Measurement; Water quality sampling;	Seep above B-1 Pond. Determine hydrologic conditions in support of seep aquatic biota monitoring.
SP6	Walnut Creek	Spring Flow Measurement; Water quality sampling;	Seep in gully east of OU 2. Determine hydrologic conditions in support of seep aquatic biota monitoring.
SP7	No Name Gulch	Spring Flow Measurement; Water quality sampling; Isotope sampling	Present Landfill Seep. Determine hydrologic conditions in support of seep aquatic biota monitoring. Determine isotope input to land fill pond.
SP8	Rock Creek	Spring Flow Measurement; Water quality sampling; Isotope sampling	Lindsey ranch pond spring, west. Determine hydrologic conditions in support of seep aquatic biota monitoring. Determine flow rate for estimating stream gain/loss in main creek. Determine environmental isotope background.
SP9	Rock Creek	Spring Flow Measurement; Water quality sampling; Isotope sampling	Lindsey ranch pond spring, east. Determine hydrologic conditions in support of seep aquatic biota monitoring. Determine flow rate for estimating stream gain/loss in main creek Determine environmental isotope background.
SP10	Rock Creek	Spring Flow Measurement; Water quality sampling; Isotope sampling	Unnamed spring complex NE of Lindsey ranch; Determine hydrologic conditions in support of seep aquatic biota monitoring; Determine flow rate for estimating stream gain/loss in main creek. Determine environmental isotope background.

Key:
STIE Stream location from original Woman Creek Gain/Loss Study
ST New stream gauging location.
SP New spring gauging location.

3.2.1 Siting of Flow-Measurement Locations

In general, calibrated flumes (Fedors and Warner, 1993) will be used to make the flow measurements. Existing primary flow measuring devices (flumes and weirs) will be used to the extent possible in the Woman Creek and Rock Creek basins. In addition to available existing equipment, flumes have been fabricated for this study to the same specifications as those of the existing calibrated flumes. In the case of small flows, such as associated with individual seepage discharges, volumetric measurements will be made using calibrated devices as detailed in the OP SW.04, Discharge Measurement (DOE, 1992f). The measurements at the upstream and downstream ends of individual stream reaches will be made synoptically so as to minimize errors in the measurements and accurately depict the gains/losses within the reach.

Fedors and Warner (1993) sited the locations of flow measurements in Woman Creek at intermittent spacing along Woman Creek during July and August when low flows dominated. The siting criteria of actual observations of flow in the stream and adjacent springs, along with RFETS personnel's past observations were used to site the locations of gain/loss stream-flow measurements in the Rock Creek basin (Figure 3). The length of stream reach sections depend upon actual and past field observations, but also are based on indicators such as riparian vegetation, stream geometry (channel width and slope), and changes in these factors. When riparian vegetation and stream channel vegetation consist of large trees and/or patches of cattails, rushes, willows, or "seep vegetation" upslope from the channel, the reach will be assumed to be a gaining section. Channel sections where there is scrub brush or little vegetation is present will be inferred to be losing reaches for purposes of locating stream-flow measurement points.

3.2.2 Flow-Measurement Procedures

The current OP SW.04 (DOE, 1992f), for stream-flow measurements at temporary locations does not anticipate the conditions which are prevalent in the Woman Creek and Rock Creek basins at the RFETS. These conditions include the inability to excavate the channel each time a flume is temporarily installed; rocky, cobblely, and sandy channel bottoms and sides leading to large leakage problems; and relatively steep channel bottom slopes requiring adjustable legs to level the flumes. These conditions were overcome during the design and operation of a similar gain/loss stream-flow program in Woman Creek and are documented by Fedors and Warner (1993). Cutthroat flumes were manufactured and calibrated in the Colorado State University (CSU) hydraulics laboratory. A large plastic apron was attached to the upstream end of the flumes and sandbags used to reduce the leakage to acceptable values (usually less than 10 percent of the total measured discharge) during stream-flow measurements. After installation, the flume water levels were allowed to stabilize for approximately 15 to 30 minutes before final readings were taken. Once a flume size was determined to be appropriate for a specific measurement site, the same flume was used at that site for each round of monitoring. In this way, the measurements were consistent from month to month. This procedure will be used for this current study of gain/loss measurements.

The calibration by CSU assumed that the general equation for flow in a flume is given by

$$Q = C_m (h_a)^{n_m} \tag{1}$$

where Q is the discharge in cubic feet per second (cfs), h_a is the staff gauge reading at the inlet portion of the flume in feet, C_m and n_m are unitless coefficients which are specific to each flume. The coefficients were obtained from calibration measurements for each flume made at CSU (Fedors and Warner, 1993). The validation data were fitted to a form of Equation (1) and the coefficients C_m and n_m of the power equation calculated. These coefficients for the four cutthroat flumes are given in Table 3 below.

TABLE 3
CUTTHROAT-FLUME CALIBRATION COEFFICIENTS

Flume Name	C_m	n_m
Delta Blue	0.724	1.680
Alpha Lou	1.368	1.631
Beta Sue	1.345	1.649
Gamma Jean	1.939	1.638

Results of the CSU calibration studies also are shown geographically on Figures 4 through 7. A typical set of stream-flow measurement stage results and resulting discharge calculations are shown in Table 4 for selected Woman Creek sites. These types of calculations will continue to be made for Woman Creek and this technique will be used for the sites selected on Rock Creek. Judgements as to gaining and losing reaches will be made, based upon the difference in measured stream flow from upstream to downstream within a given reach as shown in Table 4. Where existing and ongoing surface-water discharge monitoring is being undertaken by RFETS, such as gauging stations GS001, GS002, GS005, and GS006 in the Woman Creek basin (Figure 3 and Table 4), data supplied by RFETS from these sites will be used in the gain/loss calculations.

TABLE 4
WOMAN CREEK GAIN/LOSS DATA - OU 5 - APRIL 6-8, 1993[1)]

Date	Site	Time (hr:min)	Flume	Inlet Head (ft)	Outlet Head (ft)	Estimated Leakage (%)	Calculated Flow (cfs)	Adjusted Flow (cfs)[2)]
4/6/93	GS005	11:50:59	ASI 9.5"	0.048	---[3)]	0.0	0.03	0.03
	1	---	---	---	---	---	---	---
	2	11:51:00	Delta Blue	0.540	0.150	0.0	0.26	0.26
	3	11:24:00	Beta Sue	0.370	0.085	0.0	0.26	0.26
	4	11:18:00	Gamma Jean	0.310	0.065	0.0	0.28	0.28
	4	11:18:00	Gamma Jean	0.310	0.065	0.0	0.28	0.28
	5	13:51:00	Alpha Lou	0.200	0.065	0.0	0.10	0.10
	8	13:40:00	Beta Sue	0.450	0.100	5.0	0.36	0.38
	6	13:59:00	Delta Blue	0.250	0.050	0.0	0.07	0.07
	7	14:25:00	Delta Blue	0.250	0.050	0.0	0.07	0.07
	GS006	14:25:00	ASI 9.5"	0.079	---	0.0	0.06	0.06
4/7/93	4	08:24:00	Gamma Jean	0.440	0.110	0.0	0.51	0.51
	5	08:25:00	Alpha Lou	0.22	0.065	0.0	0.12	0.12
	8	08:51:00	Beta Sue	0.600	0.135	2.5	0.58	0.59
	9	10:18:00	ASI 9.5"	0.350	---	0.0	0.62	0.62
	10	10:52:00	Alpha Lou	0.740	0.175	5.0	0.84	0.88
	11	11:02:00	Gamma Jean	0.610	0.190	5.0	0.86	0.91
	12	12:47:00	Alpha Lou	0.805	0.190	5.0	0.96	1.01

TABLE 4
WOMAN CREEK GAIN/LOSS DATA - OU5 - APRIL 6-8, 1993, Continued.

Date	Site	Time (hr:min)	Flume	Inlet Head (ft)	Outlet Head (ft)	Estimated Leakage (%)	Calculated Flow (cfs)	Adjusted Flow (cfs)[2]
4/8/93	13	09:14:00	Beta Sue	0.275	0.090	0.0	0.16	0.16
	14	09:59:00	Delta Blue	0.250	0.050	0.0	0.07	0.07
	15	09:47:00	Delta Blue	0.410	0.220	0.0	0.16	0.16
	12	09:17:00	Alpha Lou	0.615	0.150	2.5	0.62	0.63
	13	09:14:00	Beta Sue	0.275	0.090	0.0	0.16	0.16
	16	09:25:00	Gamma Jean	0.585	0.155	0.0	0.81	0.81
	17	09:30:00	ASI 9.5"	0.410	---	0.0	0.78	0.78
	18	---	Not done, Flume capacities exceeded			---	---	---
	C1	10:12:00	6" V-notch	381.300	gpm	0.0	0.85	0.85

1) Source: EG&G Surface Water Division.
2) Adjusted flow reflects corrections for estimated leakage during flow measurement.
3) --- means no data.

3.3 Site-wide Spring/Seep Inventories, Data Analysis, and Reporting

This subtask will consist of two components: (1) two comprehensive site-wide spring and seep inventories; and (2) regular monitoring at selected seeps and springs identified in the inventories.

3.3.1 Comprehensive Site-Wide Spring/Seep Inventories

The site-wide inventories will be conducted during high- and low-flow conditions in 1995 and will be integrated with the gain/loss measurement surveys described in Section 3.2. The purpose of the site-wide inventories is to determine the relative flow and general water-quality and isotopic characteristics of individual springs and seepage areas at the RFETS. Typically, high seep/spring flows occur during the months of February through May, and low flows occur during the months of June through January. However, if evapotranspiration is an important component of the low-flow scenarios, seep/spring discharges may actually increase after the first killing frost, when evapotranspiration decreases. The comprehensive inventories will include the collection of basic hydrologic data for each seep/spring, such as the apparent geologic source and spring type, seepage flow conditions and flow rates, and field water-quality variable measurements (water temperature, pH, specific conductance, and dissolved oxygen). The locations of known seeps/springs will be based upon recent spring and seep mapping conducted by the United States Geological Survey (USGS) and recent wetlands mapping conducted by the U.S. Army Corps of Engineers (ACE, 1994). Approximately 200 individual seep/spring locations will be assessed during the inventories.

At each spring/seep inventoried, a site description using OP SW.12 (DOE, 1992f), will be done. Of particular importance is identification of vegetation associated with each inventoried spring/seep and the apparent geologic unit from which each spring/seep discharges. Geologic identification will be done using the most recent surficial geologic/soil maps and field identification of rock/soil types at the spring/seep location. These data, along with other data will be recorded on Form SW.12A (or a modified version of SW.12A) provided in OP SW.12 (DOE, 1992f). Any modifications will be submitted to RFETS staff for review and approval. Upon approval, a DMR to SW.12 will be submitted.

Upon completion of the spring/seep inventory, a comprehensive seep map will be developed. This map will exclusively and accurately identify and delineate seeps caused by natural groundwater discharges. This map will be based on the hydrologic data collected during the inventory, using the 1994 wetlands map (ACE, 1994) as a base. Once the map is drafted, it will be field-verified.

Spring/seep flow rates will be measured using one of the techniques in OP SW.04 (DOE, 199f). Field water-quality variable measurements for water temperature, pH, specific conductance, and dissolved oxygen will be done in accordance with OP SW.02 (DOE, 1992f).

3.3.2 Regular Spring/Seep Monitoring

Up to ten springs and seepage areas will be monitored twice monthly for discharge and selected field water-quality variables during high-flow periods and monthly during low-flow periods at locations selected for aquatic biota monitoring under the EPMD Ecological Monitoring Program (Figure 3). Experience with similar studies in Woman Creek indicate that, as discussed above, the high-flow period is generally during the months of February through May, and the low-flow period is during June through January of a typical year. These generalizations are highly dependent upon precipitation both prior and during any given year.

At the spring flow-measurement sites, discharges will be measured with one of the calibrated portable cutthroat flumes used for the gain/loss studies or volumetrically using a calibrated container as described in OP SW.04 (DOE, 1992f). It is anticipated that most spring discharges will not exceed 10 gallons per minute (gpm) (0.022 cfs). Field water-quality variables (temperature, pH, specific conductance, and dissolved oxygen) also will be measured at each of the 10 spring sites during each visit to more fully characterize the water. The water-quality field variables will be measured using OP SW.02 (DOE, 1992f). Flow monitoring of seeps will be conducted at locations selected for aquatic biota and stream gain/loss monitoring.

Limited sampling of seep/spring discharges for water-quality and environmental isotope analyses will be performed at the direction of the CTR. Approximately 10 seeps/springs will be sampled monthly during the sampling period. Sampling will be in accordance with OP SW.03 (DOE, 1992f). Analytes will include TAL metals, VOCs, and water-quality constituents. Sampling will be conducted during the regularly scheduled site visits. Environmental isotope sampling at seep monitoring sites will occur during high and low flow conditions in coordination with stream gain/loss sampling activities described in Section 3.2, above.

4.0 DATA NEEDS AND DATA QUALITY OBJECTIVES (DQOs)

DQOs are qualitative and quantitative statements derived from the outputs of the first six steps of a seven-step process. These first six steps are designed to clarify the study objective; define the most appropriate type of data to collect; determine the most appropriate conditions from which to collect the data; and specify tolerable levels of decision errors that will be used as the basis for establishing the quantity and quality of data needed to support the decision. DQOs are then used to develop a scientific and resource-effective data collection design in the seventh step (EPA, 1994).

The DQO process is a strategic planning approach based on the Scientific Method that is used to prepare for a data collection activity. It provides a systematic procedure for defining the criteria that a data collection design should meet including when to collect samples, where to collect samples, what the tolerable level of decision errors is for the study and how many samples to collect (EPA, 1994).

The DQO process is used to assure that the type, quantity, and quality of environmental data used in decision making will be appropriate for the intended application. In addition, they are designed to guard against committing resources to data collection efforts that do not provide a defensible resolution to a decision that must be made (EPA, 1994).

EPA's (1994) guidance on the DQO process defines the seven steps as follows:

(1) State the Problem: Concisely describe the problem to be studied. Review prior studies and existing information to gain an acceptable understanding of the problem.

(2) Identify the Decision: Identify the decision that will solve the problem using new data.

(3) Identify the Inputs to the Decision: Identify the information that needs to be learned and the measurements that need to be taken to resolve the decision.

(4) Define the Study Boundaries: Specify the conditions (time periods and situations) to which decisions will apply and within which the data should be collected.

(5) Develop a Decision Rule: Define the parameter of interest, specify the action level, and integrate previous DQO outputs into a single statement that describes a logical basis for choosing among alternative actions.

(6) Specify Tolerable Limits on Decision Errors: Define the decision maker's tolerable decision error rates based on a consideration of the consequences of making an incorrect decision.

(7) Optimize the Decision: Evaluate information from the previous steps and generate alternative data collection designs. Choose the most resource-efficient design that meets all DQOs.

Through application of the DQO process, site-specific RFI/RI goals are established and data needs are identified for achieving those goals. The studies described in this Work Plan are not RFI/RIs. Because the studies take place within the boundaries of some of the OUs, it is anticipated that some of the data resulting from these studies may be used as background and/or supporting information for selected RCRA/CERCLA OU RFI/RIs. Therefore, this section discusses the DQO process as it relates to these studies. Formal DQOs have been established for each of the OUs within whose boundaries these study locations lie (DOE, 1992a; 1992b)

4.1 Data Users

Data users are the decision makers and the primary and secondary data users. The decision makers for these studies are the technical management personnel of RFETS and DOE. Primary data users are those individuals involved in ongoing study activities. These are RFETS personnel and RFETS subcontractor technical staffs. They will be involved in the collection and analysis of the data and in the preparation of all associated reports. Secondary data users are those users that rely on the results of these studies to support their activities. Secondary data users may include RFETS and RFETS subcontractor personnel working on OUs or site-wide projects, DOE, EPA, and CDPHE.

4.2 Assessment of Existing Data

Numerous reports have been developed describing hydrogeologic conditions, water quality, and stream-flow data collected at RFETS. The following partial list includes recent reports most directly related to the Seepage Characterization study:

- Characterization of Physical and Hydraulic Properties of Surficial Materials and Groundwater/Surface Water Interaction Study at Rocky Flats Plant (Fedors and Warner, 1993)
- 1995 Hydrologic Characterization Report (publication expected May, 1995)
- Geologic Characterization Report (DOE, 1991a)
- OU 5, TM15 (DOE, 1994b)
- The Hydrologic Data Summary for OU 5 (DOE, 1994d)
- Final Phase II RFI/RI Aquifer Test Report, Rocky Flats Plant, 903 Pad, Mound, and East Trenches Areas (Operable Unit No. 2) (DOE, 1992d)
- Phase II Geologic Characterization Data Acquisition, Surface Geological Mapping of Rocky Flats Plant and Vicinity, Jefferson and Boulder Counties, Colorado (DOE, 1992c)
- Surface water sampling locations and results from the 1989 Site-Wide Surface Water and Sediment Geochemical Characterization Reports (DOE, 1991)

- Results from environmental isotope analyses of groundwater and surface water samples presented in the 1995 Groundwater Geochemistry Report (DOE, 1995a)

- Wetlands locations identified in the U. S. Army Corps of Engineers Wetlands Mapping and Resource Study (ACE, 1994; DOE, 1995c)

- Monitoring well locations posted as of December 1, 1994, on the 1995 Well Location Map (DOE, 1995b)

Historical and current conditions of OUs 5 and 6 are summarized in Section 2.0 of this Work Plan. Documents specific to OUs are also referenced in Section 2.0 for more detailed information.

The data contained in the sources listed above are not sufficient for the purposes of the projects listed in Section 1.2. Specific examples of data gaps include:

- Stream-flow data has been collected along Woman Creek in OU 5 but not in the upper reaches of the creek or in Rock Creek;

- Limited spring and seep mapping has been conducted by the USGS, and wetlands mapping has been conducted by the U.S. Army Corps of Engineers. However, seep mapping is not comprehensive and data have not been collected for seeps and springs detailing their geologic sources, flow rates, water quality, etc.

- Potentiometric surface maps have been developed for RFETS; however, more control points are needed to define flow conditions in drainages east of the Rocky Flats Alluvium extent.

- Aquifer test data in the form of hydraulic conductivities have been collected. However, hydraulic characteristics of the Woman and Walnut Creek valley fill alluvium below the terminal ponds are unknown.

- Background conditions for environmental isotopes in surface water have not been established and can only be established in Rock Creek due to the influence of

Rocky Flats Lake and plant operations in Woman Creek and plant operations in Walnut Creek.

Section 1.1 provides more details on the kinds of data that are needed and on the objectives of the data collection effort. Data gaps identified in the DQOs and QAAs specific to the Phase I RFI/RIs of OUs 5 and 6 are detailed in the Work Plans for the investigations of these OUs. Refer to Sections 4.0 (DQOs) and 10.0 (QAA) of these documents (DOE, 1992a; 1992b).

4.3 Objectives and Approach

The DQO process outlined in the EPA guidance document (EPA, 1994) is not entirely applicable to the Seepage Characterization because its intent is not focused on characterization of contaminants but of collection of data for hydrologic interpretation. The design of the study was based on experience gained from, and data gaps recognized in, the information produced from other similar studies rather than quantification of environmental decisions, decision error rates, and uncertainty embodied in steps 5 and 6 of the DQO process. Nor is the quantitative method used in the DQO process as applicable to the types of data needed to support hydrologic interpretation and characterization, as it is to that needed to support environmental characterization and remediation decisions. Limited sampling for contaminants in the groundwater will be performed as a part of the well point program in OUs 5 and 6. The DQO's established for OUs 5 and 6 will be followed during the sampling of these well points. The DQOs pertaining to OUs 5 and 6 can be found in the Work Plans for these OUs (DOE, 1992a; 1992b).

4.4 The DQO Process

4.4.1 Statement of the Problem

The location, flow rate, water chemistry, and source of water in seeps located throughout the RFETS buffer zone, and the interactions between the surface water and groundwater is not well documented in many areas of concern. The nature and occurrence of contamination at selected spring and seep sites is unknown and need to be assessed. Potential seasonal surface and groundwater interactions are also unknown and needs to be assessed. Additional data are needed to provide improved control of the alluvial potentiometric surface to fill in strategic gaps in our knowledge of the shallow groundwater flow system. Several projects need support and/or data that will be provided by the Seepage Characterization. These include the OU 5 and OU 6 Remedial Investigations, the 1995 Aquifer Testing Program, the Site-Wide Groundwater Flow Model, the 1995 Environmental Isotope Project, the OU 5 Surface Water Model, and the Site-Wide Hydrogeologic Characterization. DQOs and QAAs specific to the Phase I RFI/RIs of OUs 5 and 6 are detailed in the Work Plans for the investigations of these OUs. Refer to Sections 4.0 (DQOs) and 10.0 (QAA) of these documents (DOE, 1992a; 1992b) when applying DQOs to monitoring locations falling within OUs.

4.4.2 Identify the Decisions

To resolve the problem, data must be collected and analyzed to provide information to fill the data gaps discussed above. Decisions to be made include what data to collect, the locations of monitoring points, monitoring frequency, and sampling locations.

4.4.3 Identify the Inputs to the Decisions

The information that had to be learned to resolve the decision includes where the data gaps exist spatial and temporally, what monitoring frequency would suffice to collect a representative set of data, and the characteristics of the most efficient sample location network. These questions were applied to the Seepage Characterization core needs. Project managers having data needs that could be satisfied by hydrologic data collection activities were then surveyed and their proposed sampling/monitoring scenarios were incorporated into the design developed for the Seepage Characterization.

4.4.4 Define the Boundaries of the Study

Seven gain/loss measurement sites along Woman Creek downstream of Pond C-2 were dry most of the time (Fedors and Warner, 1993). These sites, and two additional sites, have been relocated to the western end of the Woman Creek watershed between the western boundary of RFETS and Highway 93 (Figure 3). The 39 additional gain/loss monitoring locations will be established in Rock Creek between approximately the west RFETS boundary and State Highway 128. After establishment of the stream gain/loss measurement network, monthly discharge measurements will be taken manually through September 1995. The flow measurements of individual stream reaches will be taken synoptically in order to accurately depict gains/losses within that reach.

The preliminary locations of 200 known seeps/springs will be based upon recent spring and seep mapping conducted by the USGS and recent wetlands mapping conducted by the U.S. Army Corps of Engineers (ACE, 1994). Two site-wide inventories will be conducted, one during high-flow and another during low-flow conditions. Ten sites will be selected for monthly or semi-monthly flow and water-quality monitoring.

4.4.5 Develop Decision Rules

The parameters of interest include flow rate and water chemistry of the surface water, and the inter-relationship between surface water and groundwater. This study involves data acquisition and analyses for site-wide characterization. The EPA guidance identifies specification of the action level and integration of previous DQO outputs into a single statement (that describes a logical basis for choosing among alternative actions) as additional activities in developing decision rules. Because this study does not involve decisions regarding remediation, and because actions are predetermined, determination of action levels and alternative actions are not applicable.

4.4.6 Specify Acceptable Limits on Decision Errors

Decision error rates are not applicable to this data acquisition and analysis study for site-wide characterization. The decision error rates are used to establish appropriate performance goals for limiting uncertainty in the data (EPA, 1994). Establishing acceptable error rates is necessary prior to determining the appropriate number of data (samples or tests) necessary to support the decision with a specified level of confidence. However, as mentioned previously, the statistically-based DQO process is not entirely applicable to the Seepage Characterization Program because hydrologic characterization decisions were made based on experience gained from other similar studies, rather than quantitative evaluation of environmental data to "choose among alternative actions (Step 5 of the DQO process)." In addition, the quantitative method in the DQO process is not applicable to the type of data needed to support characterization activities.

4.4.7 Optimize the Design

The required streamflow and water-quality data will be gathered through September 1995. At that time, the data will be analyzed and the monitoring network can be revised if the data needs are not being satisfied or if data gaps become apparent. As discussed previously, the DQO process is not entirely applicable to the Seepage Characterization Program. The DQO process is most directly applicable to decisions to be made with regard to optimizing design of environmental characterization and remediation of contaminated sites. Furthermore, decisions were made based on experience gained from other similar sites rather than on the basis of quantitative decision making, with specified error rates and uncertainties, as embodied in Steps 5 and 6 of the DQO process. The quantitative DQO process is often not applicable to the types of data needed to support a hydrogeologic characterization. Table 5 summarizes the DQOs for the Seepage Characterization.

TABLE 5
DATA QUALITY OBJECTIVES

Data Need	Sample/Analysis Activity	Analytical Level	Data Use
Identify and monitor seep and spring locations	Visual inspection Measurement of field parameters Perform isotope analytical testing of samples Perform analytical testing of samples Flow measurements	I & II	Site-Wide Hydrogeologic Characterization Environmental Isotope Study Aquatic Biota Monitoring Program
Characterize stream gain/loss	Flow measurements Perform isotope analytical testing of samples Water level measurements	I	OU Support Surface Water Modeling Support Site-Wide Hydrogeologic Characterization

TABLE 5
DATA QUALITY OBJECTIVES, Continued.

Data Need	Sample/Analysis Activity	Analytical Level	Data Use
Characterize occurrence and nature of contamination at selected spring and seep locations	Install wellpoints, perform analytical testing on samples. Water level measurements	I, II, III, and IV	OU Support Site-Wide Groundwater Model Potentiometric Surface Map data. Water Balance Equations Aquifer Testing

5.0 FIELD SAMPLING PLAN

5.1 Groundwater Sampling

Following well-point development, one-time groundwater samples and appropriate Quality Assurance/Quality Control (QA/QC) water samples will be collected using the techniques described in OP GW.06, Groundwater Sampling (DOE, 1992c) (Table 6). Water samples will be collected for volatile organic compounds (VOCs), total and dissolved metals, water-quality constituents, total and dissolved radionuclides, tritium, deuterium (^{2}H) and oxygen (^{18}O) isotopes, and potentially other organic or inorganic constituents. Field water-quality measurements for water temperature, pH, specific conductance, and dissolved oxygen will be made at the time of sampling of each well point. It is likely that up to three field visits to each well point will be needed to obtain the necessary water volumes from the well points for the constituent suites anticipated. For these constituent suites, up to 16 liters of water may be necessary for a complete suite of chemical analyses for the desired analytes. Experience at the RFETS has shown that some well points may not yield the necessary water volumes in the three site visits. Concerns related to locations/numbers of specific well points will be discussed with the CTR to achieve consensus on a reasonable course of action for this aspect of the field investigations.

5.2 Stream-Flow and Seep/Spring Sampling

During Seep/Spring Inventory and Stream-Flow activities, surface-water samples and appropriate QA/QC water samples will be collected using the techniques described in OP SW.03, Surface Water Sampling (Table 6). Samples will be collected and analyzed for tritium, ^{2}H and ^{18}O

TABLE 6
FIELD SAMPLING SUMMARY

Activity	Sample Type	Analytes	Frequency
Well Point Sampling	Groundwater Per Procedure GW.06, Groundwater Sampling (DOE, 1992f), and the methods described in Section 3.0.	<u>Analytical</u> VOCs total and dissolved metals Water Quality total and dissolved radionuclides tritium deuterium (^2H) oxygen (^{18}O) <u>Field</u> water levels temperature pH specific conductance dissolved oxygen	One-time* QA/QC: duplicates - 1/20 rinsates - 1/day trip blanks - 1/cooler containing VOCs *water levels associated with seep/spring monitoring locations will be taken at same frequency of seep/spring field parameters.
Seep/Spring Inventory	Surface Water Per Procedure SW.02, Field Measurement of Surface Water Field Parameters (DOE, 1992f) Per Procedure SW.03, Surface Water Sampling	<u>Field</u> temperature pH specific conductance dissolved oxygen <u>Analytical</u> oxygen (^{18}O) deuterium (^2H) enriched tritium	Two times, once during high-flow inventory and once during low-flow inventory.

TABLE 6
FIELD SAMPLING SUMMARY, Continued.

Activity	Sample Type	Analytes	Frequency
Regular Seep/Spring Monitoring (Ten springs selected for aquatic biota and stream gain/loss monitoring).	Surface Water Per Procedure SW.02, Field Measurement of Surface Water Field Parameters (DOE, 1992f)	Field temperature pH specific conductance dissolved oxygen	Two/month during high-flow season, one/month during low-flow season.
Seep/Spring	Per Procedure SW.03, Surface Water Sampling	TAL metals VOCs Water Quality	Monthly during regularly scheduled visits. QA/QC: duplicates - 1/20 rinsates - 1/day trip blanks - 1/cooler containing VOCs

isotopes. Field water-quality measurements for water temperature, pH, specific conductance, and dissolved oxygen will be made during the site-visit.

Field sampling data will be entered into DATACAP and provided to the Rocky Flats Environmental Data-Base System (RFEDS) data-base with the requisite documentation for well-point and sample tracking. The water samples will be shipped to the assigned laboratories under appropriate chain-of-custody procedures. RFETS will contract directly with the analytical laboratories for the appropriate analyses.

6.0 GENERAL FIELD PROCEDURES

6.1 Equipment Decontamination

All equipment decontamination activities will be performed in accordance with field operations OPs (FO.03, FO.04, FO.07, and FO.12) (DOE, 1992f). The field geologist will be responsible for ensuring that these OPs are properly followed.

6.2 Environmental Material Handing, Labeling and Disposal

It is not expected that environmental materials such as soil cuttings will be generated as a result of the studies associated with this Work Plan. However, if any such materials are generated, environmental material handling, labeling, and disposal will be performed in accordance with field operations and geotechnical OPs (FO.06, FO.07, FO.08, FO.10, FO.13, FO.23, and GT.02) (DOE, 1992f).

The field geologist will be responsible for ensuring that all materials handling and labeling, transfer and management of drums, and associated paperwork and data management is completed in a timely manner. The field supervisor will inspect all associated records at the completion of each field subtask to ensure the applicable criteria has been met. In addition, the field supervisor will ensure that the following duties are executed by subcontractor personnel:

- arranging for the appropriate drums,
- ensuring that waste materials are not co-mingled and are properly segregated,
- ensuring that drums are properly filled, labeled, and positioned in the field,
- ensuring that all documentation is completed properly, and a tracking system is implemented to account for each drum,

- assisting with inspections, and
- arranging for the transfer of accountability of drums to RFETS.

6.3 Permits

Permits must be obtained from RFETS prior to performing work. The subcontractor Field Supervisor will work with the CTR to obtain these permits prior to the commencement of field activities. The permits are required to meet DOE requirements. The following permits are anticipated:

- Permit authorizing intrusive work (OP GT.10)
- Buffer Zone Permit
- Radiation Work Permit
- Project specific land-use permits
- Categorical Exclusion for actions related to the installation of well points installed in drainages to maintain compliance with NEPA and requirements of 10 CFR 1021 and 10 CFR 1022
- Migrating Birds
- Notification of intent to drill wells

6.4 Field Communications

The subcontractor's Field Supervisor will ensure that field communications are maintained in accordance with OP FO.11 (DOE, 1992f).

6.5 Records and Reports

The subcontractor's Project Manager will prepare a schedule to accomplish the work. This schedule will contain performance and cost measurement data. The subcontractor's Project Manager will provide bi-monthly project-status reports detailing cost and schedule performance by the 15th of month and the last working day of each month. The report, due on the 15th of the following month, will report actual costs of the previous month. The report due on the last day of the month will provide estimated costs for the two week reporting period. The project-status report will contain Budgeted Cost of Work Scheduled (BCWS), Budgeted Cost of Work Performed (BCWP), and Actual Cost of Work Performed (ACWP) by year-to-date and reporting period for each subtask. The project-status report will also provide detail on progress for the current two week reporting period as well as identify the work planned to be performed within the next reporting period. Problems and issues of potential concern will also be detailed. The format of the project-status reports will be determined by the CTR.

The contractor Field Supervisor will ensure that field records are maintained in accordance with OPs applicable to each subtask. Field records will also be maintained in accordance with FO.14, as applicable (DOE, 1992f).

The following is a list of reports and delivery schedules identified:

- Bi-monthly cost/schedule performance report to be submitted on the 15th and last working day of each month.
- Site-Specific Health-and-Safety Plan Addenda.
- Final Well-Point Field Activities Report describing activities, analytical results, and incorporating technical review comments. A brief field-activities letter report describing the methods used in performing the Seepage Characterization, as described above, will

be prepared for submittal. Five copies of the draft and 15 copies of the final Well-Point Field Activities Report will be submitted. The report will include methods, locations of well points, analytical results, and a summary table of well-point completions including, total depth, length of perforated tubing, water level before and after development, and other data. Field log sheets for well-point installation, well-point development, water-sample collection, and field conditions will be attached to the report as appendices.

- Final Stream Gain/Loss, Spring/Seep Inventory, and Seep Monitoring Report for the 1995 fiscal year incorporating technical review comments, scheduled for submittal on September 29, 1995.

- At the end of the contract period, original master paper copies (that is, reproducible hard copies) and electronic copies of all reports will be provided to RFETS. Electronic word-processing files will be in the form of WordPerfect 5.1 or newer version and delivered on 3.5-inch, not compressed, diskettes in IBM PC-DOS compatible format. All CAD, GIS, and other program files used to create the maps, plates, drawings, and appendices in the reports will also be submitted to RFETS. These documents will be delivered to RFETS in the format approved by the Records' Management Department. All equipment and software purchased for this task-order contract will also be delivered to RFETS personnel.

The results of water quality and environmental isotope sampling will be reported under separate deliverables prepared for the Ecological Monitoring and Environmental Isotope Programs by RFETS personnel.

6.6 Health and Safety

6.6.1 Site-Specific Health-and-Safety Plan

Health and safety requirements for this project are established in the project SSHSP and its associated Addenda. RFETS guidelines for applicable health-and-safety practices are referenced in these documents. The SSHSP addresses field-related activities associated with the following activities:

- Shallow Well-Point Design, Installation, Development, and Sampling;
- Stream Gain/Loss Monitoring and Reporting; and
- Site-Wide Spring/Seep Inventories, Data Analysis, and Reporting.

6.6.2 Site-Specific Training Requirements

Site-specific training and experience unique to the RFETS are required for the performance of the subtasks described in this Work Plan. Specifically, this training may include, but is not limited to:

- General Employee Training (GET) (initial training and refresher every 2 years),
- Radiation Worker Level II,
- Respirator Indoctrination Computer Based Training (CBT),
- 3-Day Onsite Hazardous Waste Operations Field Experience Checklist,
- Buffer Zone Indoctrination,
- Site-Specific Safety Briefing,
- DOT Training (for sample shippers),
- DATACAP Training (for sample manager),
- Computer Security CBT (if using a DOE-owned computer),
- Waste Generator Training (for drum handlers, non-radiation),
- Nuclear Materials Safeguards CBT (if unescorted in the Protected Area),
- Decontamination Facility Training Briefing,
- QA Overview,
- RCRA CBT,
- RCRA Supervisory Checklist, and
- required reading (Standard Operating Procedures (OPs), SSHSP, etc..), as applicable.

All site-specific training is provided by RFETS. The subcontractor's Project Manager will coordinate training schedules for subcontractor personnel and its subcontractors with the RFETS ERM training compliance coordinator and collect proof-of-training-compliance records prior to the initiation of specific field activities.

7.0 QUALITY ASSURANCE ADDENDUM (QAA)

The following section is the QAA which establishes the specific QA controls applicable to the field investigation activities described in this Work Plan. This document was developed separately from the other sections of this Work Plan; therefore, the format of this section may vary slightly from the other sections.

7.1 Purpose

This section consists of the QAA for the Seepage Characterization Work Plan. The purpose of the QAA is to identify QA requirements and specific measures for implementing these requirements, which are applicable to the Seepage Characterization.

This QAA is intended to supplement the *Rocky Flats Plant Site-Wide Quality Assurance Project Plan for CERCLA Remedial Investigation/Feasibility Studies and RCRA Facility Investigations/Corrective Measures Studies Activities* (referred to as the RFETS Site-Wide QAPjP, or simply QAPjP) (DOE, 1991e). As a supplement to the QAPjP, this QAA establishes the site-specific measures and QA controls applicable to the actions described in this Work Plan.

7.2 Scope

This QAA addresses all quality-affecting activities described in the Work Plan being performed by RFETS personnel, its primary subcontractor, and the primary subcontractor's subcontractors.

The major actions within this Work Plan, to which this QAA applies, include:

- Defining data-quality objectives (DQOs)
- Collecting of field data
- Sample collection
- Sample handling and shipping
- Data analysis

7.3 Basis for Technical Activity

The work outlined in the Seepage Characterization Work Plan identifies the specific analytical needs, sampling requirements, data handling requirements and associated QA/QC requirements necessary to analyze and understand the nature of seepage conditions in the vicinity of the RFETS (Figure 1).

7.4 Basis of QA Requirements

The QAPjP was prepared to identify the QA requirements and methods applicable to the RFETS ERPD activities, as identified in the Attachment 2 of the IAG Statement of Work (DOE, 1991f). Section IV.A of the IAG specifies the minimum quality elements that the QAPjP must include, and references EPA QAMS/005/80, *Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans,* for guidance in preparing the QAPjP.

7.5 Quality Requirements

The following describes the quality requirements for the Seepage Characterization Work Plan.

7.5.1 Organization and Responsibilities

The ERPD is responsible for the overall coordination of the Seepage Characterization project. Other organizations such as the internal sampling management group and the subcontracted external laboratory will be involved with this work. Responsibilities of other organizations will be assigned by the ERPD.

The organization for this project has been structured such that quality is the responsibility of those who have been assigned the responsibility of performing the work. Conformance to established requirements shall be verified by individuals and groups not directly responsible for performing the work. The subcontractor is responsible for management and coordination of the resources dedicated to the project.

7.5.2 QA Program

The ERPD CTR is responsible for preparation and modification of this QAA and providing internal quality implementation support (including inspections and surveillance of system acceptance and performance) to assure that the quality requirements of this QAA and the QAPjP are being implemented. The QAPjP was written to address QA controls and requirements for implementing environmental restoration activities, as required by the IAG (DOE, 1991f).

The content of the QAPjP was driven by the DOE Order 5400.1, the RFETS QA Manual (RFETS QAM), and the IAG. Both, the DOE Order 5400.1 and the RFETS QAM, require a QA program to be implemented based on the American Society of Mechanical Engineers (ASME) NQA-1, *Quality Assurance Requirements for Nuclear Facilities.* The IAG specifies development of a QAPjP in accordance with the EPA QAMS-005/80, *Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans*. The 18-element format of NQA-1 was selected as the basis for both the QAPjP and subsequent QAAs with the applicable elements of QAMS-005/80 incorporated where appropriate. Figure 2-1 of Section 2.0 of the QAPjP illustrates where the 16 QA elements of QAMS-005/80 are integrated into the QAPjP and also into this QAA (DOE, 1991e). Section 2.0 of the QAPjP also identifies other DOE Orders and QA requirement documents to which the QAPjP and this QAA are responsive.

The controls and requirements addressed in the QAPjP are applicable to Work Plan activities, unless specified otherwise in this QAA. Where site-wide actions are applicable to Work Plan activities, the applicable section of the QAPjP is referenced in this QAA. This QAA addresses additional and site/project specific QA controls and requirements that are applicable to Work Plan activities. Many of the QA requirements specific to the Work Plan are addressed in the various Work Plan sections and may also be referenced in this QAA.

7.5.2.1 Training

The *minimum personnel qualification* and training requirements that are applicable to RFETS and subcontractor staff for RFETS ERPD activities are addressed in Section 2.0 of the QAPjP (DOE, 1991e). All RFETS and subcontractor personnel that perform quality-affecting activities on this project shall have qualification records that document they are qualified to perform their assigned tasks. The ERPD CTR shall identify any RFETS area-specific and/or specialized training requirements that are applicable to project personnel performing field work.

Job-specific training for field personnel will include but not be limited to:

- OSHA 40-hour Hazardous Waste Operations training
- OSHA 24-hour Field Experience Checklist
- RCRA CBT
- RFETS Environmental Management Standard Operating Procedures (OPs) listed in Table 7
- Laboratory Analytical Procedures that are applicable to their assigned tasks
- Radiation Worker Level II
- Designated Waste Generator will be RCRA Waste Generator Qualified

In addition to procedures training, RFETS and subcontractor personnel shall receive training on (1) the requirements of the QAPjP, and (2) the Seepage Characterization Work Plan (including this QAA). This training must be recorded by the subcontractor's Project Manager, with verifiable documentation of training submitted to the ERPD CTR prior to implementing the sampling and analysis activities described in the Work Plan.

RFETS and subcontractor personnel shall also be qualified to perform the tasks they have been assigned. Personnel qualifications must be documented, with documentation of qualifications verified by the ERPD CTR in accordance with ERPD Administrative Procedure 3-21000-ADM-02.02, *Personnel Qualifications* (DOE, 1994a).

TABLE 7
FIELD AND ADMINISTRATIVE STANDARD OPERATING PROCEDURES
(DOE, 1992f)

	Volume I: Field Operations
5-21000-OPS-FO.01	Air Monitoring and Dust Control
5-21000-OPS-FO.02	Field Document Control
5-21000-OPS-FO.03	General Equipment Decontamination
5-21000-OPS-FO.04	Heavy Equipment Decontamination
5-21000-OPS-FO.05	Handling of Purge and Development Water
5-21000-OPS-FO.06	Handling of Personal Protective Equipment
5-21000-OPS-FO.07	Handling of Decontamination Water and Wash Water
5-21000-OPS-FO.08	Handling of Drilling Fluids and Cuttings
5-21000-OPS-FO.09	Handling of Residual Samples
5-21000-OPS-FO.10	Receiving, Labeling, and Handling Environmental Materials Containers
5-21000-OPS-FO.11	Field Communications
5-21000-OPS-FO.12	Decontamination Facility Operations
5-21000-OPS-FO.13	Containerizing, Preserving, Handling and Shipping of Soil and Water Samples
5-21000-OPS-FO.14	Field Data Management
5-21000-OPS-FO.15	Photoionization Detectors (PIDs) and Flame Ionization Detectors (FIDs)
5-21000-OPS-FO.16	Field Radiological Measurements
5-21000-OPS-FO.18	Environmental Sample Radioactivity Content Screening
4-B11-ER-OPS-FO.25	Shipping Limited Quantities of Radioactive Materials in Samples
	Volume II: Groundwater
5-21000-OPS-GW.01	Water Level Measurements in Wells and Piezometers
5-21000-OPS-GW.02	Well Development
5-21000-OPS-GW.05	Field Measurement of Groundwater Field Parameters
5-21000-OPS-GW.06	Groundwater Sampling
	Volume III: Geotechnical
5-21000-OPS-GT.06	Monitoring Wells and Piezometer Installation
5-21000-OPS-GT.10	Borehole Clearing

TABLE 7, Continued.
FIELD AND ADMINISTRATIVE STANDARD OPERATING PROCEDURES

	Volume IV: Surface Water
5-21000-OPS-SW.01	Surface Water Collection Activities
5-21000-OPS-SW.02	Field Measurement of Surface Water Field Parameters
5-21000-OPS-SW.04	Discharge Measurement
5-21000-OPS-SW.11	Operation and Maintenance of Stream-Gauging and Sampling Stations
5-21000-OPS-SW.12	Site Description
	Administrative Procedures Manual (DOE, 1994a)
1-50000-16.16	Corrective Action Program
2-G06-ER-ADM-05.10	Use of Controlled Scientific Notebooks
5-21000-ADM-5.01	Document Control
2-G32-ER-ADM-08.02	Evaluation of ERPD Data for Usability in Final Reports
5-21000-ADM-12.01	Control of Measuring and Test Equipment
5-21000-ADM-15.01	Control of Nonconforming Items and Activities
3-21000-ADM-17.01	Records Management
3-21000-ADM-18.03	Readiness Reviews

7.5.3 Design Control and Control of Scientific Investigations

7.5.3.1 Design Control

The Seepage Characterization Work Plan describes the general design considerations for implementing work activities, outlining sampling and analysis techniques, and describing analytical requirements.

The QAPjP considers activities that generate analytical data, which requires collection and analysis of environmental samples, to be scientific investigations (DOE, 1991e). Controls for scientific investigations include:

- Developing data quality objectives;
- Collecting and analyzing samples according to approved procedures;
- Establishing and implementing quality controls; and
- Reducing and reporting data in a controlled manner (according to approved procedures).

7.5.3.2 Data Quality Objectives

Site-specific Seepage Characterization objectives/data needs and corresponding methods of sampling/analysis are outlined in Table 5 of the Seepage Characterization Work Plan. This table lists the analytical levels that are appropriate to these objectives/data needs and uses. (These analytical levels are discussed and described in Appendix A of the QAPjP.) The analytical levels for the Seepage Characterization investigations include Levels I through IV.

DQOs quantitatively and qualitatively describe the uncertainty that decision makers are willing to accept in results derived from environmental data. DQOs were established to make decisions with a 95% level of confidence (based on the EPA Decision Error Feasibility Trials (DEFT), Version 3.01, EPA, 1994).

Precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters are indicators of data quality. PARCC goals are summarized in Table 8 below.

TABLE 8
PARCC PARAMETER SUMMARY (Source DOE, 1994e)

	RADIONUCLIDES	ANALYTICAL
PRECISION	RPD[1)] < 200% for Pu and Am RPD, 30% all others	RPD < 20% (Liquid)
ACCURACY	Detection Limits in GRRASP (DOE, 1990a)	Comparison of LCS with true values
REPRESENTATIVENESS	Based on use of OPs and Work Plans	Based on Use of OPs and Work Plans
COMPARABILITY	Based on use of OPs and Work Plans	Based on use of OPs and Work Plans
COMPLETENESS	90% Usable 50% Lab Validation	90% Usable 50% Lab Validation

1) Relative Percent Difference

Precision can be defined as how well sample measurement values compare with each other. This comparison can be quantified by the Relative Percent Difference (RPD) value. An RPD of $\leq$ 20% will be considered acceptable for analytical results in liquids. An RPD of $\leq$ 200% will be considered acceptable for plutonium and americium radiochemistry samples and 30% for all other isotopes. The RPD of plutonium and americium radiochemistry samples is higher than analytical samples, because these isotopes are extremely sensitive to mesoscopic and microscopic heterogeneities within the sample. Because the analytical program for the Seepage Characterization will utilize the analytical methods referenced in the GRRASP (DOE, 1990a), these objectives are applicable to the Seepage Characterization. These objectives are reproduced here in Appendix A.

Accuracy can be defined as the agreement of the measured value with the true value of a parameter. For analytical and radiochemistry purposes, accuracy is indicated by the comparison of laboratory control samples to their true values.

Representativeness is based on sampling locations specified in the Work Plan.

Comparability is established by use of DOE and EPA approved standard OPs and analytical/radiochemistry laboratory methods. Field and administrative OPs were listed in Table 7. Laboratory methods are listed in Table 9 and a specific listing of all methods and analytes is attached (See Attachment 1, Title 40 of the Code of Federal Regulation Part 264, Appendix IX). Detection limits for all methods also are given in the GRRASP (DOE, 1990a). When deviations from the OPs occur, or when new or nonstandard procedures are implemented, a Scientific Notebook System (SNS) will be used as the primary means of documenting quality-affecting information (analytical method changes are requested from the program chemists and documented in the case narratives).

TABLE 9
LABORATORY STANDARD OPERATING PROCEDURES

ANALYTICAL SUITE:	CONTROLLING DOCUMENTS:
◦ VOCs	Title 40 of the Code of Federal Regulation (CFR) Part 264.
◦ SVOCs • Metals	Appendix IX. All laboratory analyses will also adhere to protocols specified in Parts A and B of the GRRASP (DOE, 1990a).
• Radionuclides	Part B of the GRRASP (DOE, 1990a).
• Environmental Isotopes	Quality Assurance Document, University of Waterloo, Ontario, Canada (1993).

Completeness is defined as usable data from ≥ 90% of all planned field samples. This will include ≥ 50% of the usable data as validated with respect to analytical and radiochemical laboratory analyses.

7.5.3.3 Quality Control

Field-sampling quality control will consist of collecting field duplicate samples at a minimum of 1 per 20 samples, collecting equipment rinsate blanks at a rate of 1 per 20 samples or once per day, whichever is more frequent, and collecting trip blanks for VOC analysis. Analytical laboratory QC for soil sample analyses shall be as specified in the GRRASP (DOE, 1990a).

7.5.3.4 QA Monitoring

To assure the overall quality of the sampling and analysis activities associated with the Work Plan for the Seepage Characterization project, field oversite inspections will be conducted during sampling and analysis activities. Field oversite inspections to be conducted by the ERPD Environmental Quality Support will include periodic field inspections, or surveillances.

7.5.3.5 Data Reduction, Validation, and Reporting

Data evaluation and reporting requirements for field and laboratory data have been discussed previously in Section 7.5 of the Work Plan.

7.5.4 Document Control

Documents produced by RFETS that control the work described in this Work Plan shall be "controlled" to ensure that key project personnel receive accurate and up-to-date information. Such documents shall be controlled in accordance with Section 6.0 of the QAPjP (DOE, 1991c) and with ERM Procedure 3-21000-ADM-5.01, *Document Control* (DOE, 1994a).

7.5.5 Control of Purchased Items and Services

Procurement documents for items and services procured under this project, including services for conducting field sampling and analysis, shall be prepared, handled, and controlled in accordance with the requirements and methods specified in Section 4.0 of the QAPjP (DOE, 1991e) and in ERPD Procedure ADM-4.01, *Procurement Document Control* (DOE, 1994a), including retention of purchase order receipts, contracts or any other documentation related to the integrity/traceability of the purchased product or service.

Subcontractors that provide services in support of the Work Plan activities will be selected and evaluated as outlined in Section 7.0 of the QAPjP (DOE, 1991c). This includes pre-award evaluation/audit of proposed subcontractors as well as periodic assessment of the acceptability of contractor performance during the project. Any items or materials that are purchased for use during the sampling, analysis, and other Work Plan activities that have the ability to affect the quality of the data should be inspected upon receipt.

7.5.6 Identification and Control of Equipment/Items

Samples shall be identified, handled, containerized, shipped, and stored in accordance with ERPD Operating Procedure 5-21000-OPS-FO.13, *Containerization, Preserving, Handling, and Shipping of Soil and Water Samples* (DOE, 1992f). Sampling identification and chain-of-custody (COC) will be maintained through the application of Section 8.0 of the QAPjP (DOE, 1991e) and of Procedure 5-21000-OPS-FO.13 which provides instructions for preparing COC forms.

A sample COC will be initiated at the time the samples are collected and maintained through all transfers of custody until the sample is received at the testing laboratory. Samples shall be logged in upon receipt at the analytical laboratory and sample tracking throughout the analytical process shall be maintained in accordance with laboratory procedures.

7.5.7 Control of Sampling and Analysis Processes

The overall process of collecting and analyzing samples require control. The processes are controlled by adhering to the Work Plan and the sampling and analytical procedures referenced. The requirements for sample collection are addressed in Section 5.0 of the Work Plan; sample analyses are addressed in Section 5.0 of the Work Plan; and data input is addressed in Section 6.5 of the Work Plan.

7.5.8 *Inspection and Assessment*

Quality-affecting activities are subject to inspection and assessments. These assessments will be performed formally in accordance with RFETS procedures (e.g., Procedures 3-21000-ADM-10.01 and/or -ADM-18.02 (DOE, 1994a)), or informally as requested by line management. The work place and working records shall be accessible during normal working hours for verification or audit by RFETS or their representatives during the performance of this project.

Any nonconformances identified during formal assessments shall be documented with Nonconformance Reports in accordance with Section 15 of the QAPjP (DOE, 1991e) and ERPD Administrative Procedure 3-21000-ADM-15.01, *Control of Nonconforming Items and Activities* (DOE, 1994a). Independent audits of the project may be conducted by the ERPD organization in accordance with QA procedures.

7.5.9 Control of Measuring and Testing Equipment

Measuring and test equipment (M&TE) used in the screening of samples shall be selected, identified, calibrated, and maintained in accordance with the methods established in RFETS Administrative Procedure 1-50000-ADM-12.01, *Control of Measuring and Test Equipment* (DOE, 1994a). The M&TE requirements of Section 12 of the QAPjP (DOE, 1991e) are implemented through operating procedures specific to the sampling/analysis event, manufacturers instructions, and specific laboratory procedures. Field-equipment documentation will be maintained as a QA record. Laboratory equipment usage shall be conducted in accordance with the GRRASP requirements (DOE, 1990a).

An RFETS-provided equipment inventory will be maintained during periods of active field activities. The subcontractor will transfer all equipment back to RFETS upon completion of field activities. Documentation of equipment transfer will be maintained by the subcontractor's project manager.

7.5.10 Handling, Storage, and Shipping

Samples shall be packaged, transported, and stored in accordance with RFETS Procedure 5-21000-OPS-FO.13, *Containerization, Preserving, Handling, and Shipping of Soil and Water Samples* (DOE, 1992f).

7.5.11 Status of Inspections, Tests, and Operations

The status of the sampling and analysis inspections, startup Work Plan activities, log of monitoring wells and boreholes, and sustained operations shall be documented according to the requirements of Section 14.0 of the QAPjP (DOE, 1991e).

7.5.12 Control of Nonconformances

The requirements for the identification, control, evaluation, and disposition of nonconforming items, samples, and data will be implemented as specified in Section 15.0 of the QAPjP (DOE, 1991e). Items, samples, and data that do not conform to specifications and/or requirements shall be identified, segregated (where necessary to prevent inadvertent use), dispositioned, and evaluated in accordance with approved procedures. Nonconformances related to the design, construction, installation, or testing of the testing system, and any waste-related nonconformance, shall be controlled in accordance with ERPD Procedure 1-50000-ADM-15.01, *Control of Nonconforming Items, Samples, and Data* (DOE, 1994a).

7.5.13 Corrective Action

The identification, reporting, closeout, and documentation of significant conditions adverse to quality shall be accomplished in accordance with Section 16.0 of the QAPjP (DOE, 1991e) and with ERPD Procedure 1-50000-16.16, *Corrective Action Program.* Conditions adverse to quality identified by the implementing contractor shall be documented and submitted for processing as outlined in the QAPjP.

7.5.14 QA Records

Field QA records will be controlled in accordance with RFETS Procedure 5-21000- OPS-FO.02, *Field Document Control* (DOE, 1992f). Project records that are considered ERPD QA records include, but are not necessarily limited to:

- The final report, (including all appendices);
- Design documents;
- Procurement documents;
- Equipment calibration records;
- Equipment maintenance records;
- Construction/installation records;
- Supplier/subcontractor evaluations;
- Inspection records;
- Test records;
- Logbooks;
- Sampling records;
- Sample COC records;
- Analytical data packages;
- Interim and annual operating reports;
- Action plans;
- Operation manuals;
- Noncompliance Reports (NCRs);
- Corrective Action Reports (CARs);
- Audit reports;

- Surveillance reports;
- Self-assessment reports;
- Personnel training and qualification records;
- Any administrative and operating procedures referenced herein; and
- Any other project records that are used to support observations and conclusions in the final report.

All ERPD QA records generated shall be submitted to the ERPD Project File for processing according to ERPD Procedure 3-21000-ADM-17.01, *Records Management* (DOE, 1994a).

7.5.15 Quality Verification

QA inspections and surveillances will be periodically conducted by the EQS department throughout the duration of project to verify the quality of project data. Readiness reviews will be conducted according to ERPD Procedure 3-21000-ADM, 18.03, *Readiness Reviews* (DOE, 1994a).

7.5.16 Software Control

The requirements for the control of software are not applicable to the Work Plan activities to be performed during the Seepage Characterization.

APPENDIX A

Analytical Methods, Detection Limits, and Data Quality Objectives

Source: GRRASP (DOE, 1990a)

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

Analyte	Method	SW	GW	SOIL	SED	Required Detection Limits Water	Required Detection Limits Soil/Sed.	Precision Objective	Accuracy Objective
INDICATORS									
Total Suspended Solids	EPA 160.2[a]	X[u]				10 mg/L	NA	20%RPD'	80-120% LCS Recovery
Total Dissolved Solids	EPA 160.1[a]	X[f]	X[f]			5 mg/L	NA	20%RPD'	80-120% LCS Recovery
pH	EPA 150.1[a]	X[u]	X[f]			0.1 pH units	0.1 pH units	NA	±0.05 pH units
INORGANICS									
Target Analyte List - Metals		X[f]	X[f]	X	X			WATER/SOIL	WATER/SOIL
Aluminum	EPA CLP SOW[c]					200 ug/L[d]	40 mg/Kg[d]	**	***
Antimony	EPA CLP SOW[c]					60	12		
Arsenic (GFAA)	EPA CLP SOW[c]					10	2		
Barium	EPA CLP SOW[c]					200	40		
Beryllium	EPA CLP SOW[c]					5	1.0		
Cadmium	EPA CLP SOW[c]					5	1.0		
Calcium	EPA CLP SOW[c]					5000	2000		
Chromium	EPA CLP SOW[c]					10	2.0		
Cobalt	EPA CLP SOW[c]					50	10		
Copper	EPA CLP SOW[c]					25	5.0		
Cyanide	EPA 335.3 (modified for CLP)[a,d]					5	10		
Iron	EPA CLP SOW[c]					100	20		
Lead (GFAA)	EPA CLP SOW[c]					3	1.0		
Magnesium	EPA CLP SOW[c]					5000	2000		
Manganese	EPA CLP SOW[c]					15	3.0		
Mercury (CVAA)	EPA CLP SOW[c]					0.2	0.2		
Nickel	EPA CLP SOW[c]					40	8.0		
Potassium	EPA CLP SOW[c]					5000	2000		
Selenium (GFAA)	EPA CLP SOW[c]					5	1.0		
Silver	EPA CLP SOW[c]					10	2.0		
Sodium	EPA CLP SOW[c]					5000	2000		
Thallium (GFAA)	EPA CLP SOW[c]					10	2.0		
Vanadium	EPA CLP SOW[c]					50	10		
Zinc	EPA CLP SOW[c]					20	4.0		

Required Detection Limits　Precision　Accuracy

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

Analyte	Method	GW	SW	SOIL	SED	Water	Soil/Sed.	Objective	Objective
Other Metals		x[u]	x[f]	x	x			WATER/SOIL	WATER/SOIL
Molybdenum	EPA CLP SOW[a] (ICAP)					8 ug/L[d]	40 mg/Kg[d]	**	***
Cesium	EPA CLP SOW[a]					1000	200		
Strontium	EPA CLP SOW[a]					200	40		
Lithium	EPA CLP SOW[a]					100	20		
Tin	EPA CLP SOW[a]					200	40		
Other Inorganics								SOIL	SOIL
Percent Solids	EPA 160.3[d]			x	x	NA	10 mg/Kg	NA	NA
Sulfide	EPA 376.1[d]			x	x	NA	4 ug/g	Same as metals	Same as meta
TOTAL ORGANIC CARBON	EPA 9060[c]	x[u]	x[u]	x	x	1 mg/L	1 mg/L	**	***
ANIONS								WATER	WATER
Carbonate	EPA 310.1[d]	x[u]	x[u]			10 mg/L	NA	Same as metals	Same as metals
Bicarbonate	EPA 310.1[d]	x[u]	x[u]			10 mg/L	NA		
Chloride	EPA 325.2[d]	x[u]	x[u]			5 mg/L	NA		
Sulfate	EPA 375.4[d]	x[u]	x[u]			5 mg/L	NA		
Nitrate as N	EPA 353.2[d] or 353.3[d]	x[u]	x[u]			1 mg/L	NA		
Fluoride	EPA 340.2[d]	x[u]	x[u]			5 mg/L	NA		
Oil and Grease	EPA 413.2[d]	x[u]				5 mg/L	NA	**	***
Target Compound List - Volatiles	EPA CLP SOW[a]	x[u]	x[u]	x	x			WATER/SOIL	WATER/SOIL
Chloromethane	EPA CLP SOW[a]					10 ug/L	10 ug/Kg (low)[3]	**	***
Bromomethane	EPA CLP SOW[a]					10	10		
Vinyl Chloride	EPA CLP SOW[a]					10	10		
Chloroethane	EPA CLP SOW[a]					10	10		
Methylene Chloride	EPA CLP SOW[a]					5	5		
Acetone	EPA CLP SOW[a]					10	10		
Carbon Disulfide	EPA CLP SOW[a]					5	5		
1,1-Dichloroethene	EPA CLP SOW[a]					5	5		
						Required Detection Limits		Precision	Accuracy

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

Analyte	Method	SW	GW	SOIL	SED	Water	Soil/Sed.	Objective	Objective
Target Compound List - Volatiles (continued)		x[U]	x[U]	x	x			WATER/SOIL	WATER/SOIL
1,1-Dichlororethane	EPA CLP SOW					5 ug/L	5 ug/Kg(low)[3]	**	***
total 1,2-Dichloroethene	EPA CLP SOW					5	5		
Chloroform	EPA CLP SOW					5	5		
1,2-Dichloroethane	EPA CLP SOW					1	5		
2-Butenone	EPA CLP SOW					10	10		
1,1,1-Trichoroethane	EPA CLP SOW					5	5		
Carbon Tetrachloride	EPA CLP SOW					5	5		
Vinyl Acetate	EPA CLP SOW					10	10		
Bromodichloromethane	EPA CLP SOW					5	5		
1,2-Dichloropropane	EPA CLP SOW					5	5		
cis-1,3-Dichloropropene	EPA CLP SOW					5	5		
Trichloroethene	EPA CLP SOW					5	5		
Dibromochloromethane	EPA CLP SOW					5	5		
1,1,2-Trichloroethane	EPA CLP SOW					5	5		
Benzene	EPA CLP SOW					5	5		
trans-1,3-Dichloropropene	EPA CLP SOW					5	5		
Bromoform	EPA CLP SOW					5	5		
4-Methyl-2-pentanone	EPA CLP SOW					10	10		
2-Hexanone	EPA CLP SOW					10	10		
Tetrachloroethene	EPA CLP SOW					5	5		
Toluene	EPA CLP SOW					5	5		
1,1,2,2-Tetrachoroethane	EPA CLP SOW					5	5		
Chlorobenzene	EPA CLP SOW					5	5		
Ethyl Benzene	EPA CLP SOW					5	5		
Styrene	EPA CLP SOW					5	5		
Total Xylenes	EPA CLP SOW					5	5		
Target Compound List - Semi-Volatiles			x[U]	x	x			WATER/SOIL	WATER/SOIL
Phenol	EPA CLP SOW					10 ug/L	330 ug/Kg[3]	**	***
bis(2-Chloroethyl)ether	EPA CLP SOW					10	330		
2-Chlorophenol	EPA CLP SOW					10	330		
1,3-Dichlorobenzene	EPA CLP SOW					10	330		
1,4-Dichlorobenzene	EPA CLP SOW					10	330		
Benzyl Alcohol	EPA CLP SOW					10	330		
1,2-Dichlorobenzene	EPA CLP SOW					10	330		
2-Methylphenol	EPA CLP SOW					10	330		
bis(2-Chloroisopropyl)ether	EPA CLP SOW					10	330		

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

Analyte	Method	SW	GW	SOIL	SED	Required Detection Limits Water	Soil/Sed.	Precision Objective	Accuracy Objective
Target Compound List - Semi-Volatiles (continued)			X[4]	X	X			WATER/SOIL	WATER/SOIL
4-Methylphenol	EPA CLP SOW[2]					10 ug/L	330 ug/Kg[3]	**	***
n-nitroso-di-n-propylamine	EPA CLP SOW[2]					10	330		
Hexachloroethane	EPA CLP SOW[2]					10	330		
Nitrobenzene	EPA CLP SOW[2]					10	330		
Isophorone	EPA CLP SOW[2]					10	330		
2-Nitrophenol	EPA CLP SOW[2]					10	330		
2,4-Dimethylphenol	EPA CLP SOW[2]					10	330		
Benzoic Acid	EPA CLP SOW[2]					50	1600		
bis(2-Choroethoxy)methane	EPA CLP SOW[2]					10	330		
2,4-Dichlorophenol	EPA CLP SOW[2]					10	330		
1,2,4-Trichlorobenzene	EPA CLP SOW[2]					10	330		
Naphthalene	EPA CLP SOW[2]					10	330		
4-Chloroaniline	EPA CLP SOW[2]					10	330		
Hexachlorobutadiene	EPA CLP SOW[2]					10	330		
4-Chloro-3-methylphenol	EPA CLP SOW[2]					10	330		
2-Methylnaphthalene	EPA CLP SOW[2]					10	330		
Hexachlorocyclopentadiene	EPA CLP SOW[2]					10	330		
2,4,6-Trichlorophenol	EPA CLP SOW[2]					10	330		
2,4,5-Trichlorophenol	EPA CLP SOW[2]					50	1600		
2-Chloronaphthalene	EPA CLP SOW[2]					10	330		
2-Nitroaniline	EPA CLP SOW[2]					50	1600		
Dimethylphthalate	EPA CLP SOW[2]					10	330		
Acenaphthylene	EPA CLP SOW[2]					10	330		
2,6-Dinitrotoluene	EPA CLP SOW[2]					10	330		
3-Nitroaniline	EPA CLP SOW[2]					50	1600		
Acenaphthene	EPA CLP SOW[2]					10	330		
2,4-Dinitrophenol	EPA CLP SOW[2]					50	1600		
4-Nitrophenol	EPA CLP SOW[2]					50	1600		
Dibenzofuran	EPA CLP SOW[2]					10	330		
2,4-Dinitrotoluene	EPA CLP SOW[2]					10	330		
Diethylphthalate	EPA CLP SOW[2]					10	330		
4-Chlorophenol Phenyl ether	EPA CLP SOW[2]					10	330		
Fluorene	EPA CLP SOW[2]					10	330		
4-Nitroaniline	EPA CLP SOW[2]					50	1600		
4,6-Dinitro-2-methylphenol	EPA CLP SOW[2]					50	1600		
N-nitrosodiphenylamine	EPA CLP SOW[2]					10	330		
4-Bromophenyl Phenyl ether	EPA CLP SOW[2]					10	330		
Hexachlorobenzene	EPA CLP SOW[2]					10	330		
Pentachlorophenol	EPA CLP SOW[2]					50	1600		

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

Analyte	Method	SW	GW	SOIL	SED	Required Detection Limits Water	Required Detection Limits Soil/Sed.	Precision Objective	Accuracy Objective
Target Compound List - Semi-Volatiles (continued)			X[u]	X	X			WATER/SOIL	WATER/SOI
Phenanthrene	EPA CLP SOW					10 ug/L	330 ug/Kg[3]	**	***
Anthracene	EPA CLP SOW					10	330		
Di-n-butylphthalate	EPA CLP SOW					10	330		
Fluoranthene	EPA CLP SOW					10	330		
Pyrene	EPA CLP SOW					10	330		
Butyl Benzylphthalate	EPA CLP SOW					10	330		
3,3'-Dichlorobenzidine	EPA CLP SOW					20	660		
Benzo(a)anthracene	EPA CLP SOW					10	330		
Chrysene	EPA CLP SOW					10	330		
bis(2-ethylhexyl)phthalate	EPA CLP SOW					10	330		
Di-n-octyl Phthalate	EPA CLP SOW					10	330		
Benzo(b)fluoranthene	EPA CLP SOW					10	330		
Benzo(k)fluoranthene	EPA CLP SOW					10	330		
Benzo(a)pyrene	EPA CLP SOW					10	330		
Indeno(1,2,3-cd)pyrene	EPA CLP SOW					10	330		
Dibenz(a,h)anthracene	EPA CLP SOW					10	330		
Benzo(g,h,i)perylene	EPA CLP SOW					10	330		
Target Compound List - Pesticides/PCBs			X[u]	X	X			WATER/SOIL	WATER/SOI
alpha-BHC	EPA CLP SOW					0.05 ug/L	8.0 ug/Kg[3]	**	***
beta-BHC	EPA CLP SOW					0.05	8.0		
delta-BHC	EPA CLP SOW					0.05	8.0		
gamma-BHC (Lindane)	EPA CLP SOW					0.05	8.0		
Heptachlor	EPA CLP SOW					0.05	8.0		
Aldrin	EPA CLP SOW					0.05	8.0		
Heptachlor Epoxide	EPA CLP SOW					0.05	8.0		
Endosulfan I	EPA CLP SOW					0.05	8.0		
Dieldrin	EPA CLP SOW					0.10	16.0		
4,4'-DDE	EPA CLP SOW					0.10	16.0		
Endrin	EPA CLP SOW					0.10	16.0		
Endosulfan II	EPA CLP SOW					0.10	16.0		
4,4'-DDD	EPA CLP SOW					0.10	16.0		
Endosulfan Sulfate	EPA CLP SOW					0.10	16.0		
4,4'-DDT	EPA CLP SOW					0.10	16.0		
Methoxychlor	EPA CLP SOW					0.5	80.0		
Endrin Ketone	EPA CLP SOW					0.10	16.0		
alpha-Chlordane	EPA CLP SOW					0.5	80.0		

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

Analyte	Method	SW	GW	SOIL	SED	Required Detection Limits Water	Soil/Sed.	Precision Objective	Accuracy Objective
Target Compound List - Pesticides/PCBs (continued)			X^{u}	X	X			WATER/SOIL	WATER/SOIL
gamma-Chlordane	EPA CLP SOW^{f}					0.5 ug/L	80.0 mg/Kg	**	***
Toxaphene	EPA CLP SOW^{f}					1.0	160.0		
AROCLOR-1016	EPA CLP SOW^{f}					0.5	80.0		
AROCLOR-1221	EPA CLP SOW^{f}					0.5	80.0		
AROCLOR-1232	EPA CLP SOW^{f}					0.5	80.0		
AROCLOR-1242	EPA CLP SOW^{f}					0.5	80.0		
AROCLOR-1248	EPA CLP SOW^{f}					0.5	80.0		
AROCLOR-1254	EPA CLP SOW^{f}					1.0	160.0		
AROCLOR-1260	EPA CLP SOW^{f}					1.0	160.0	(Replicate Analyses)	(Laboratory Control Sample)
RADIONUCLIDES									
Gross Alpha	f,g,h,i,k,l,m,n,s	$X^{f,u}$	X^{f}	X	X	2 pCi/L	4 pCi/g	**	***
Gross Beta	f,g,h,i,k,l,m,n,s	$X^{f,u}$	X^{f}	X	X	4 pCi/L	10 pCi/g		
Uranium 233+234	f,h,i,m,n,l,s	$X^{f,u}$	X^{f}	X	X	0.6 pCi/L	0.3 pCi/g		
Uranium 235,238	f,h,i,m,n,l,s	$X^{f,u}$	X^{f}	X	X	0.6 pCi/L	0.3 pCi/g		
Americium 241	i,l,p,q,s	$X^{f,u}$	X^{f}	X	X	0.01 pCi/L	0.02 pCi/g		
Plutonium 239+240	i,l,o,p,s	$X^{f,u}$	X^{f}	X	X	0.01 pCi/L	0.03 pCi/g		
Tritium	f,g,h,m,i,l,s	X^{u}	X^{u}	X	X	400 pCi/L	400 pCi/L		
Strontium 89,90	f,h,i,m,s,l			X	X	NA	1 pCi/g		
Strontium 90 only	f,h,i,m	$X^{f,u}$	X^{f}			1 pCi/L	NA		
Cesium 137	n,i,l,m	$X^{f,u}$	X^{f}	X	X	1 pCi/L	0.1 pCi/g		
Radium 226	f,g,h,m^{b},i,s,l	$X^{f,u}$	X^{f}			0.5 pCi/L	0.5 pCi/g		
Radium 228	f,g,h,m^{b},i,s,l	$X^{f,u}$	X^{f}			1 pCi/L	0.5 pCi/g		

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

Analyte	Method	SW	GW	SOIL	SED	Readability Objective	Accuracy
FIELD PARAMETERS							
pH	1	X	X			± 0.1 pH unit	± 0.2 pH units
Specific Conductance	1	X	X			2.5 umho/cm[7] 25 umho/cm[8] 250 umho/cm[9]	± 2.5% max. error at 500, 5000, 50000 umhos/cm plus probe; ± 3.0% max error at 250, 2500, and 25000 plus probe accuracy of ± 2.0%.
Temperature	1	X	X			± 0.1°C	± 1.0°C
Dissolved Oxygen	1	X				± 0.1 mg/L	± 10%
Barometric Pressure	1						

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

** Precision objective = control limits specified in referenced method and/or Data Validation Guidelines.
*** Accuracy objective = control limits specified in referenced method (in GRRASP for radionuclides).
F = Filtered
U = Unfiltered

1. Measured in the field in accordance with instrument manufacturer's instructions. The instruments to be used are specified in Section 12.
2. Medium soil/sediment required detection limits for pesticide/PCB TCL compounds are 15 times the individual low soil/sediment required detection limit.
3. Detection limits listed for soil/sediment are based on wet weight. The detection limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.
4. Higher detection limits may only be used in the following circumstance: If the sample concentration exceeds five times the detection limit of the instrument or method in use, the value may be reported even though the instrument or method detection limit may not equal the required detection limit. This is illustrated in the example below:

   For lead:

   Method in use - ICP
   Instrument Detection Limit (IDL) - 40
   Sample Concentration - 220
   Required Detection Limit (RDL) - 3

   The value of 220 may be reported even though the instrument detection limit is greater than the RDL.

   Note: The specified detection limits are based on a pure water matrix. The detection limits for samples may be considerably higher depending on the sample matrix.
5. If gross alpha > 5 pCi/L, analyze for Radium 226; if Radium 226 > 3 pCi/L, analyze for Radium 228.
6. The detection limits presented were calculated using the formula in N.R.C. Regulatory Guide 4.14, Appendix Lower Limit of Detection, pg. 21, and follow:

$$LLD = \frac{4.66\ (BKG/BKG\ DUR)^{1/2}}{(2.22)(Eff)(CR)(SR)(e^{-\lambda t})(Aliq)}$$

$$MDA = \frac{4.66\ (BKG/Sample\ DUR)^{1/2}}{(2.22)(Eff)(CR)(SR)e^{-\lambda t}(Aliq)}$$

Where:

LLD = Lower Limit of Detection in pCi per sample unit.
BKG = Instrument Background in counts per minute (CPM).
Eff = Counting efficiency in cpm/disintegration per minute (dpm).
CR = Fractional radiochemical yield.
SR = Fractional radiochemical yield of a known solution.
λ = The radioactive decay constant for the particular radionuclide.
t = The elapsed time between sample collection and counting.
Aliq = Sample volume.
BKG DUR = Background count duration in minutes.

MDA = Minimum Detectable Activity in pCi per sample unit
BKG = same as for LLD
Eff = same as for LLD
CR = same as for LLD
SR = same as for LLD
λ = same as for LLD
t = same as for LLD
Aliq = same as for LLD
Sample DUR = sample count duration in minutes

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

7. On 500 umho/cm range.
8. On 5000 umho/cm range.
9. On 50000 umho/cm range.
a. U.S. Environmental Protection Agency Contract Laboratory Program Statement of Work for Inorganics Analysis, Multi-Media, Multi-Concentration, 7/88 (or latest version).
b. U.S. Environmental Protection Agency Contract Laboratory Program Statement of Work for Inorganics Analysis, Multi-Media, Multi-Concentration, 7/88 (or latest version). The specific method to be utilized is at the laboratory's discretion provided it meets the specified detection limit.
c. U.S. Environmental Protection Agency Contract Laboratory Program Statement of Work for Organic Analysis, Multi-Media, Multi-Concentration, 2/88 (or latest version).
d. Methods are from "Methods for Chemical Analysis of Water and Wastes," U.S. Environmental Protection Agency, 1983, unless otherwise indicated.
e. Methods are from "Test Methods for Evaluation of Solid Waste, Physical/Chemical Methods," (SW-846, 3rd Ed.), U.S. Environmental Protection Agency.
f. U.S. Environmental Protection Agency, 1979, Radiochemical Analytical Procedures for Analysis of Environmental Samples, Report No. EMSL-LV-0539-1, Las Vegas, NV, U.S. Environmental Protection Agency.
g. American Public Health Association, American Water Works Association, Water Pollution Control Federation, 1985. Standard Methods for the Examination of Water and Wastewater, 16th ed., Washington, D.C., Am. Public Health Association.
h. U.S. Environmental Protection Agency, 1976. Interim Radiochemical Methodology for Drinking Water, Report No. EPA-600/4-75-008. Cincinnati U.S. Environmental Protection Agency.
i. Harley, J.H., ed., 1975, HASL Procedures Manual, HASL-300; Washington, D.C., U.S. Energy Research and Development Administration.
j. EPA, 1982. "Methods for Organic Analysis of Municipal and Industrial Waste Water," US EPA-600/4-82-057.
k. "Handbook of Analytical Procedures," USAEC, Grand Junction Lab. 1970, page 196.
l. "Prescribed Procedures for Measurement of Radioactivity in Drinking Water," EPA-600/4-80-032, August 1980, Environmental Monitoring and Support Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, Ohio 45268.
m. "Methods for Determination of Radioactive Substances in Water and Fluvial Sediments," U.S.G.S. Book 5, Chapter A5, 1977.
n. "Acid Dissolution Method for the Analysis of Plutonium in Soil," EPA-600/7-79-081, March 1979, U.S. EPA Environmental Monitoring and Support Laboratory, Las Vegas, Nevada, 1979.
o. "Procedures for the Isolation of Alpha Spectrometrically Pure Plutonium, Uranium, and Americium," by E.H. Essington and B.J. Drennon, Los Alamos National Laboratory, a private communication.
p. "Isolation of Americium from Urine Samples," Rocky Flats Plant, Health, Safety, and Environmental Laboratories.
q. "Radioactivity in Drinking Water," EPA 570/9-81-002.
r. If the sample or duplicate result is <5 x IDL, then the control limit is ± IDL.
s. U.S. EPA, 1987. "Eastern Environmental Radiation Facility Radiochemistry Procedures Manual," EPA-520/5-84-006.

APPENDIX B

Analytical Methods, Detection Limits, and Data Quality Objectives Specific to Environmental Isotopes

				Required Detection Limits	
Analyte	Method	SW	GW	Water	Soil/Sed.
Oxygen-18	x	x^u	x^u	0.2/ml	n/a
Deuterium	y	x^u	x^u	2/ml	n/a
Tritium, enriched	z	x^u	x^u	0.8 T.U.	n/a

x. Heemskesh, A. R., 1993, Water ^{18}O by CO_2 Equilibration, Technical Procedure 13.0, Rev. 01, Environmental Isotope Laboratory, Department of Earth Sciences, University of Waterloo, 11p.

y. Heemskesh, A.R., W.A. Mark, and R.M. Weber, 1991, Deuterium by Zinc Reduction, Technical Procedure 4.0, Rev. 01, Environmental Isotope Laboratory, Department of Earth Sciences, University of Waterloo, 6p.

z. Dummie, R., 1989, Tritium Analysis, Technical Procedure 1.0, Rev. 0, Environmental Isotope Laboratory, Department of Earth Sciences, University of Waterloo, 25p.

8.0 SCHEDULE

The subcontract period of performance was originally May 11, 1994 through September 30, 1995. This period of performance would have allowed for seasonal variations in the hydrological environment to be monitored. However, due to delays in document review and approval and subsequent work authorizations, field activities are tentatively scheduled to begin in April 1995 and continue through the expiration of the original period-of-performance. Monitoring will continue after September 30, 1995 pending authorization.

9.0 STANDARD OPERATING PROCEDURES AND PROCEDURE CHANGE NOTICES

Work performed for this project will be governed by the QAPjP (DOE, 1991e). The subcontractor will comply with all applicable OPs (DOE, 1992f) for field operations as discussed in this Work Plan. The OPs identified as being applicable to the activities associated with the Seepage Characterization are listed in Table 7, presented in Section 7.0 above.

Document Modification Requests (DMRs) will be initiated in the event that deviations from the OPs are needed in order to more efficiently perform field activities or to improve upon an OP.

In addition to the above referenced OPs, the EM Radiological Guidelines (EMRG) (DOE, 1994f) and the Quality Assurance Program Description (QAPD) (DOE, 1994g) will also be followed as will 10 Code of Federal Regulations, Part 20, DOE 5480.11 (1994h), and the DOE Radiation Control Manual (DOE, 1994i).

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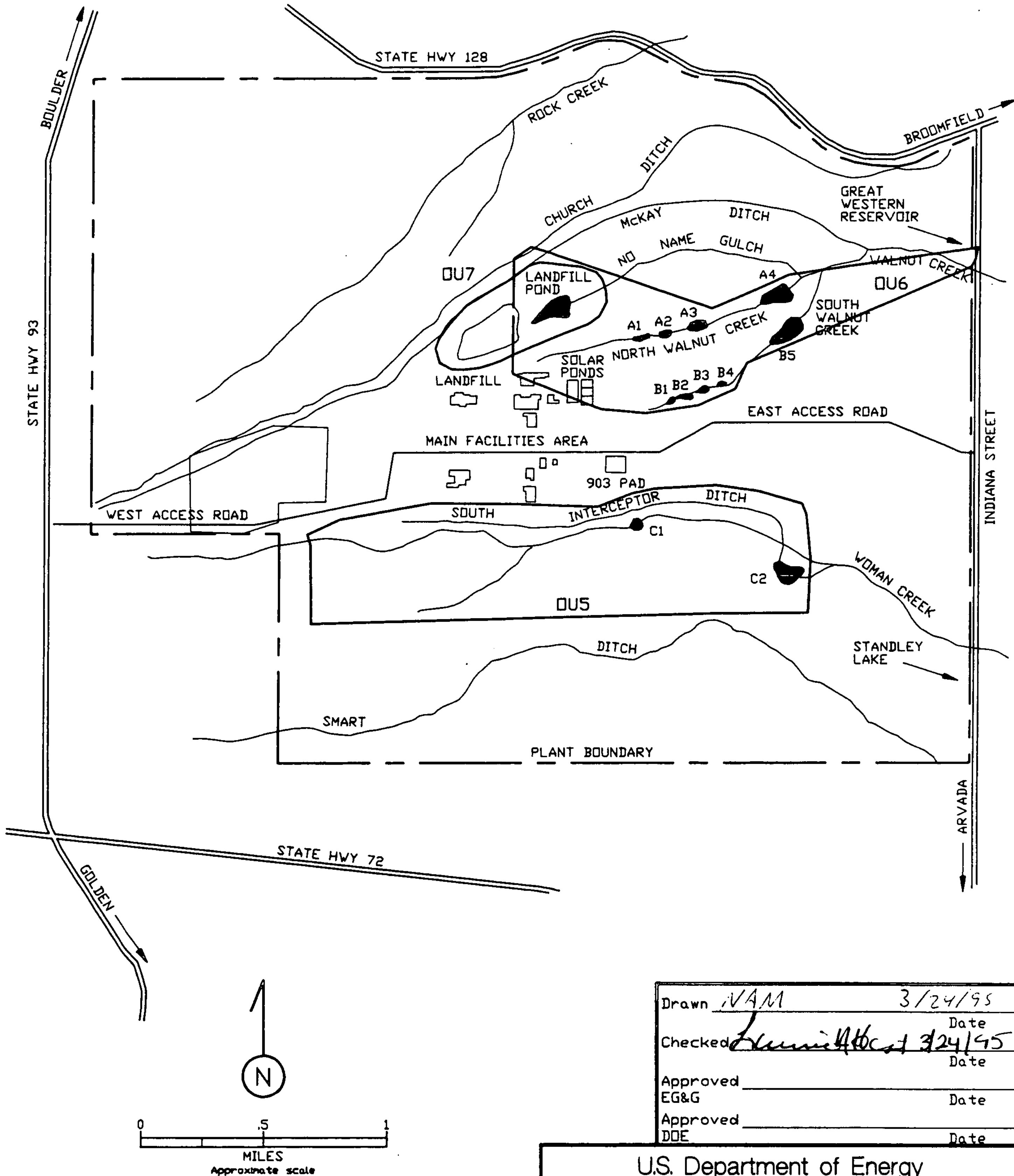

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Date

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Date

Approved EG&G

Date

Approved DOE

Date

U.S. Department of Energy
RFETS, Golden, Colorado

Seepage Characterization Project

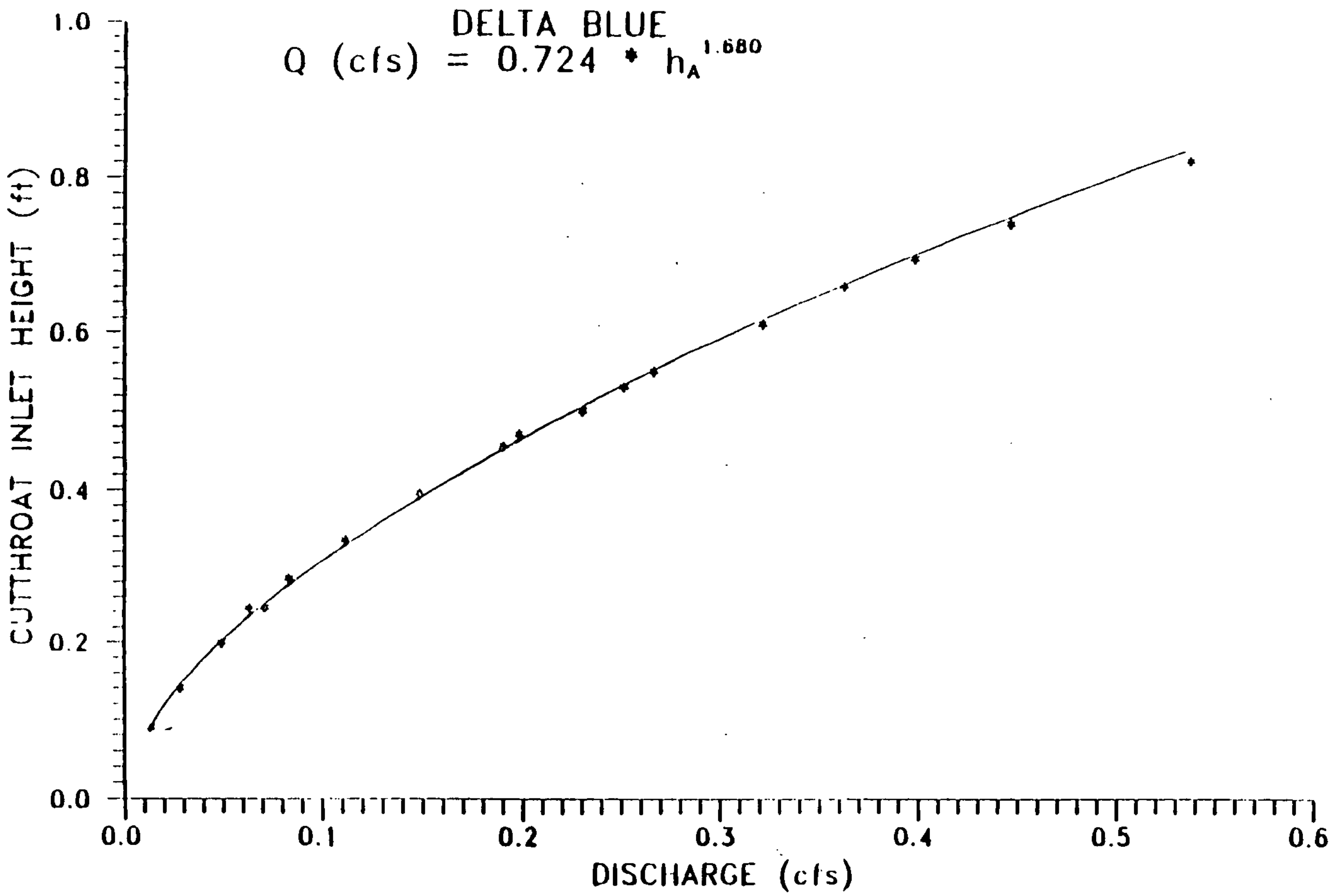
General RFETS Site Location Map

Figure 1 Status: March 1995

OU5 Generalized locations of selected operable units associated with GRSSC sites.

NOTE: Streamflow in the Rocky Flats area is to the east.

GRSF1.DWG



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Approved BG&G Date
Approved DOE Date

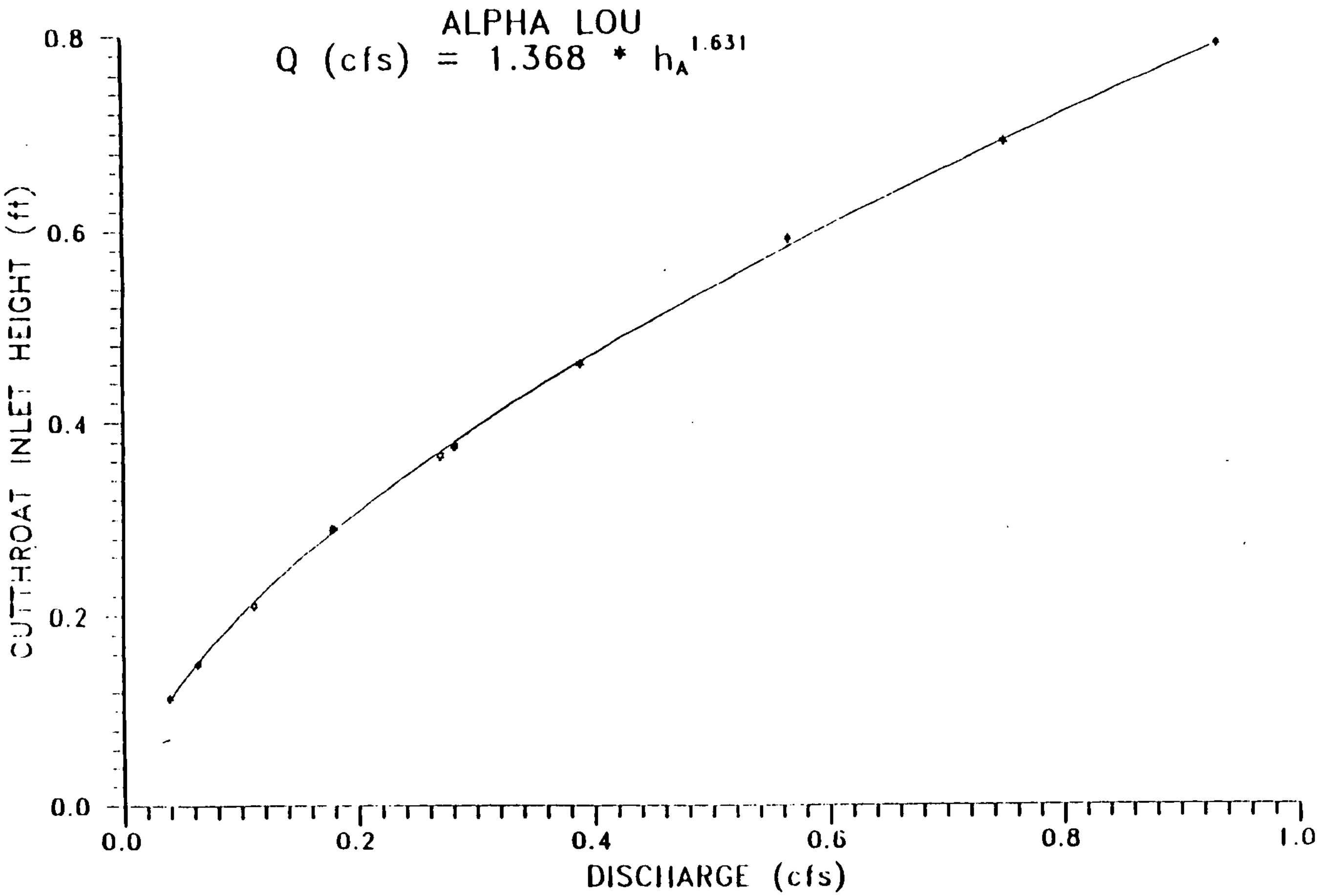
U.S. DEPARTMENT OF ENERGY
Rocky Flats ETS, Golden, Colorado

SEEPAGE CHARACTERIZATION PROJECT

Calibration Data and Best Fit Curve, Delta Blue Cutthroat Flume

FIGURE 4 Status: March, 1995

File: DELTA.DRW



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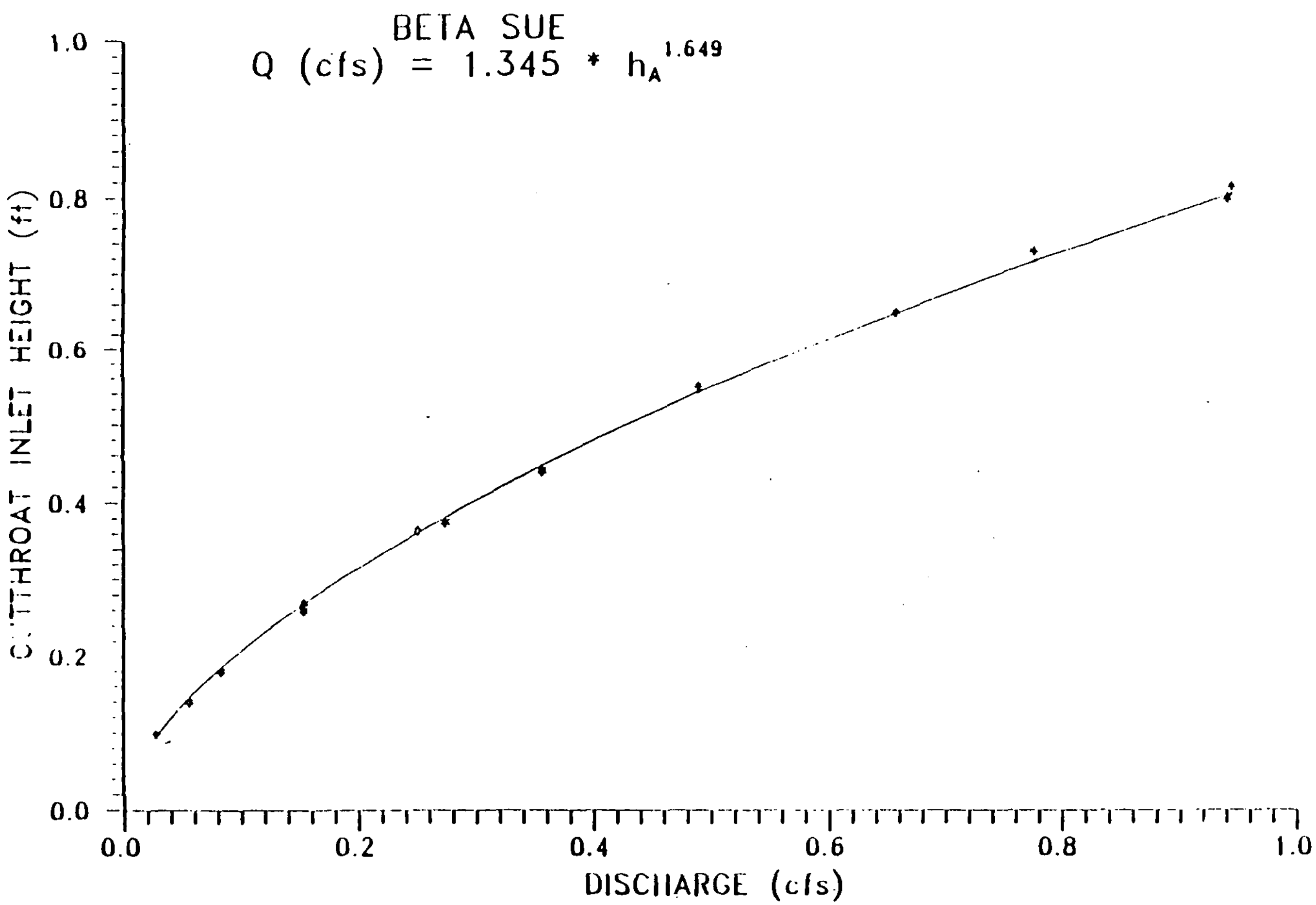
Rocky Flats ETS, Golden, Colorado

SEEPAGE CHARACTERIZATION PROJECT

Calibration Data and Best Fit Curve, Alpha Lou Cutthroat Flume

FIGURE 5 Status: March, 1995

File: ALPHA.DRW



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Approved DOE	Date

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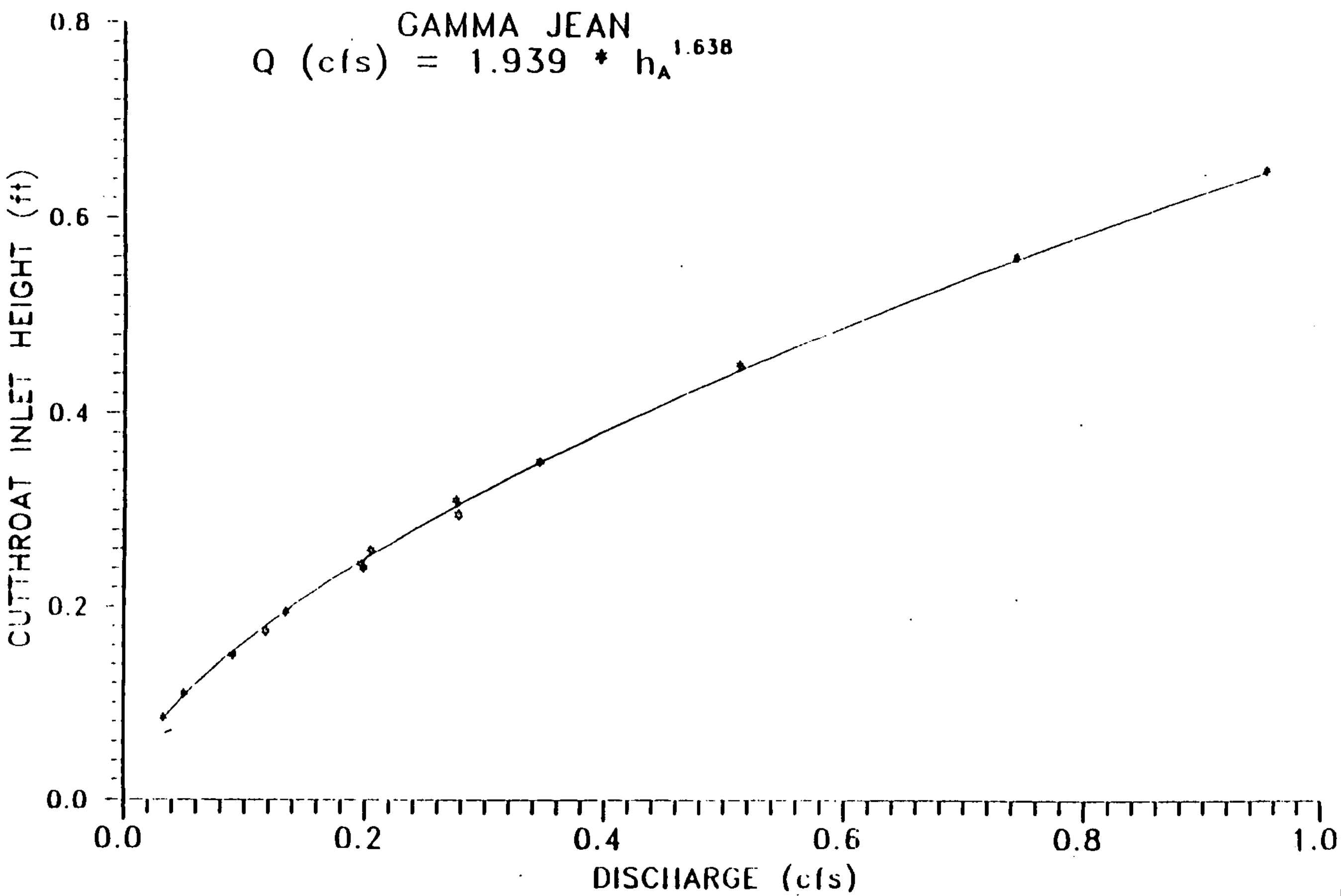
Rocky Flats ETS, Golden, Colorado

SEEPAGE CHARACTERIZATION PROJECT

Calibration Data and Best Fit Curve, Beta Sue Cutthroat Flume

FIGURE 6 Status: March, 1995

File: BETASUE.DRW



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Approved DOE	Date

U.S. DEPARTMENT OF ENERGY
Rocky Flats ETS, Golden, Colorado

SEEPAGE CHARACTERIZATION PROJECT

Calibration Data and Best Fit Curve, Gamma Jean Cutthroat Flume

FIGURE 7

Status: March, 1995

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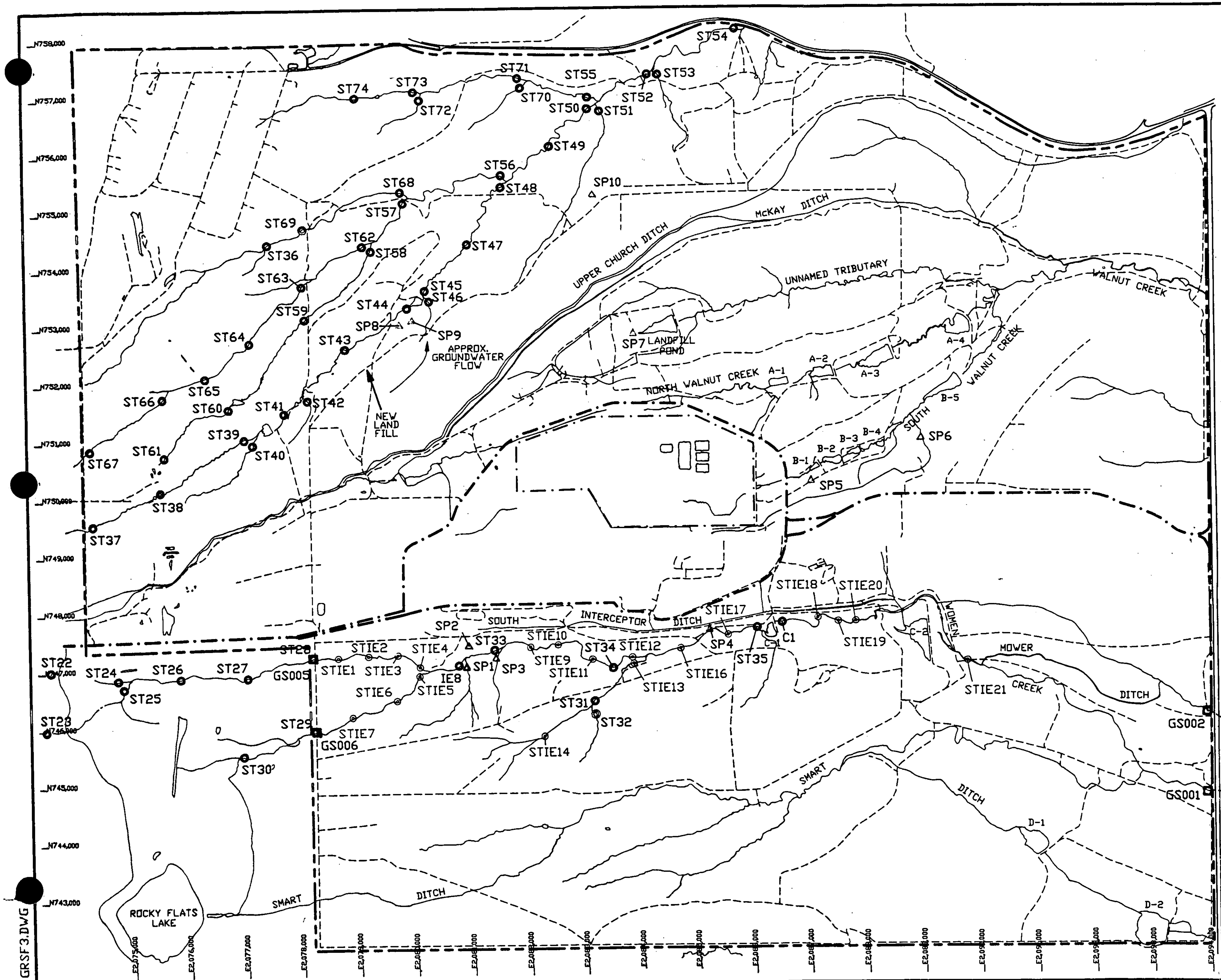

EXPLANATION

Streams and Drainages
Rocky Flats Plant Site
Rock Flats Security Zone
Rocky Flats Site Boundary
Dirt Roads

Monitoring Locations

STIE2 — Woman Creek Gain/Loss Study Stream Sites
ST44 — New Stream Sites
SP8 — Spring/Seep Sites
GS001 — Permanent EG&G Streamflow Measurement Site

1500 0 1700

1" = 1700'

Scale = 1 : 20400

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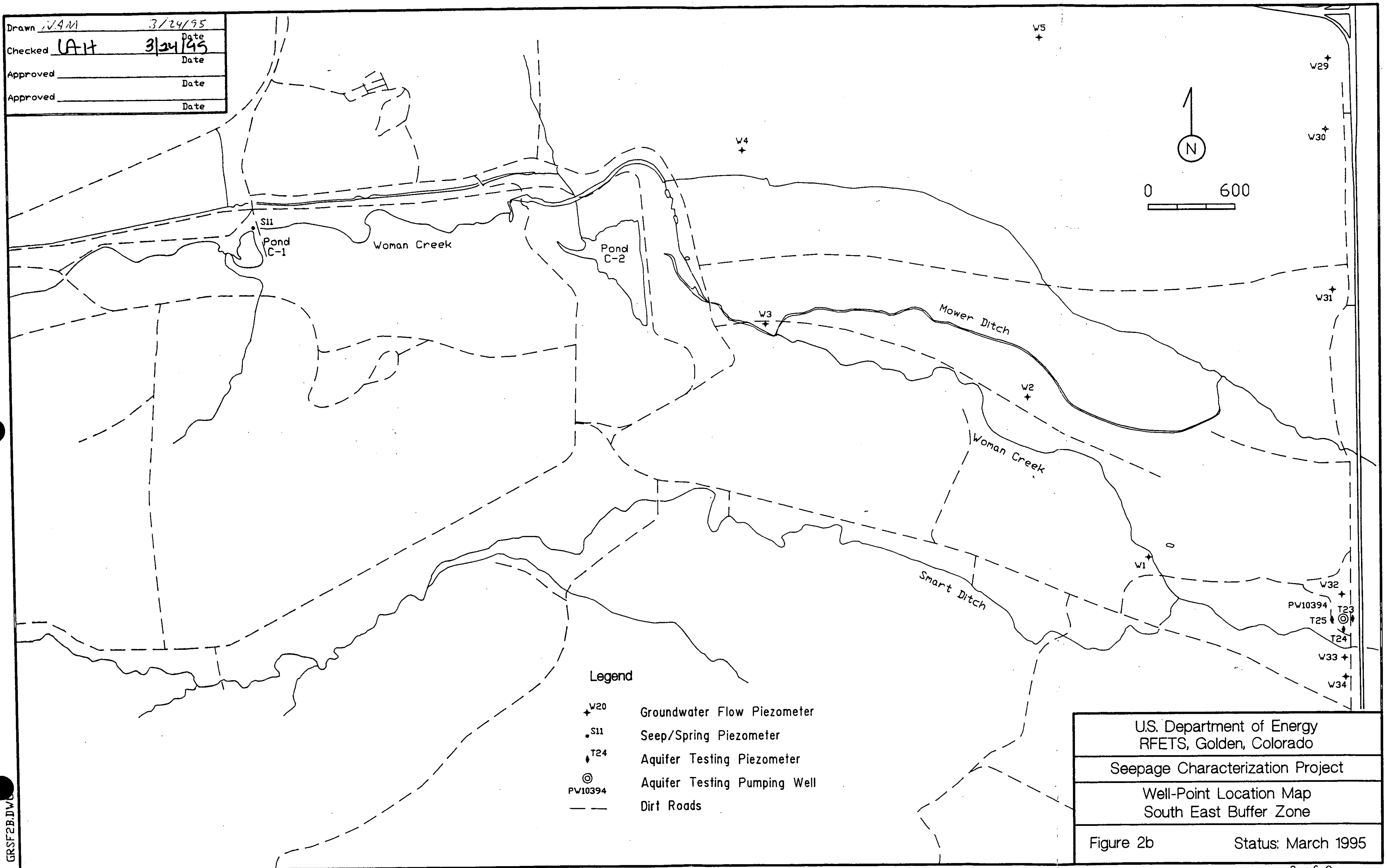
U.S. Department of Energy
RFETS, Golden, Colorado

Seepage Characterization Project

Stream and Seep
Monitoring Locations

Figure 3 Status: March 1995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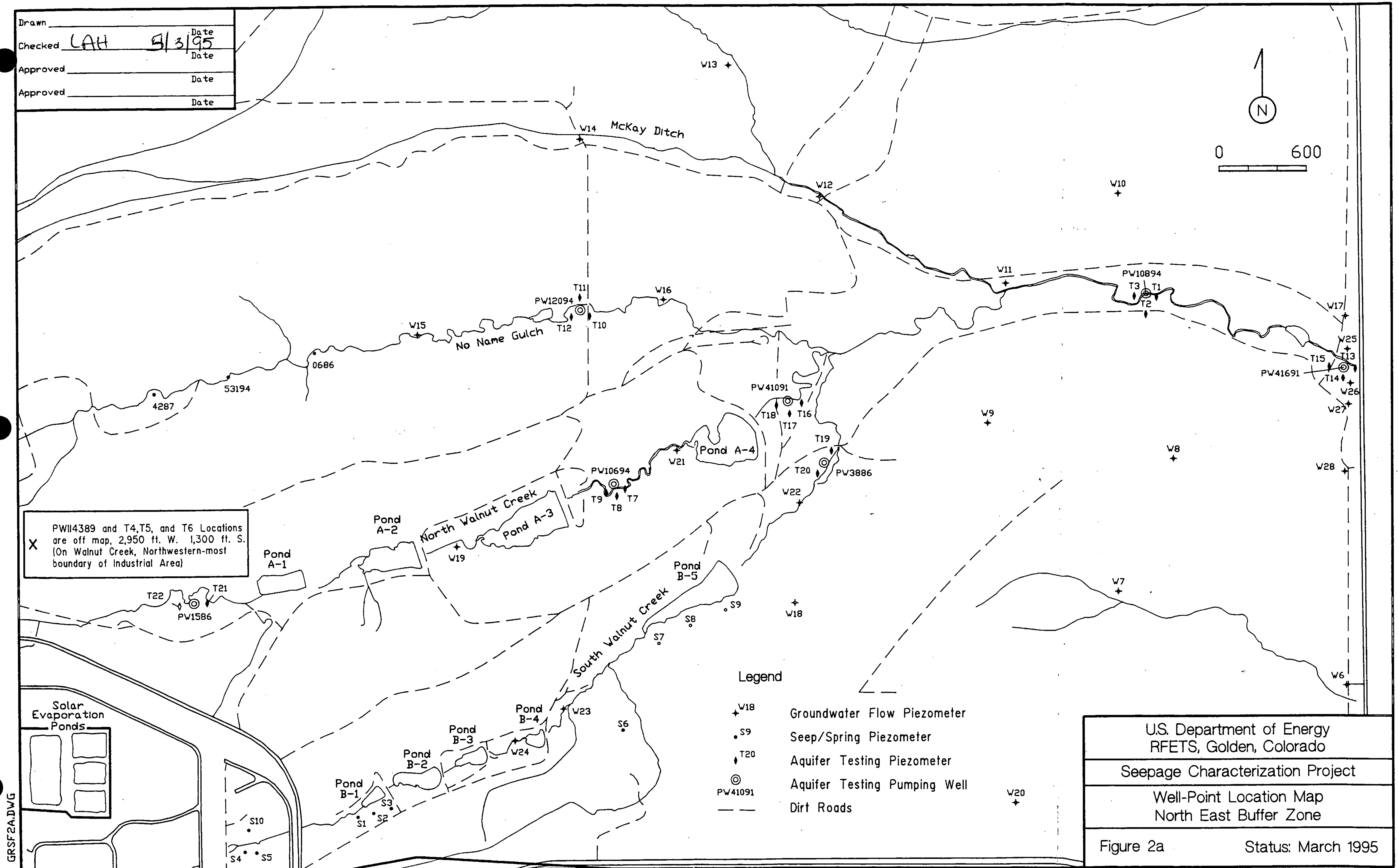
W5
W29
W4
W30
N
0 600
S11
Pond C-1
Woman Creek
Pond C-2
W31
W3
Mower Ditch
W2
Woman Creek
W1
Smart Ditch
W32
PW10394
T23
T25
T24
W33
W34
Legend
W20 Groundwater Flow Piezometer
S11 Seep/Spring Piezometer
T24 Aquifer Testing Piezometer
PW10394 Aquifer Testing Pumping Well
Dirt Roads
U.S. Department of Energy
RFETS, Golden, Colorado
Seepage Characterization Project
Well-Point Location Map
South East Buffer Zone
Figure 2b
Status: March 1995
GRSF2B.DWG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0 600
McKay Ditch
No Name Gulch
North Walnut Creek
South Walnut Creek
Pond A-1
Pond A-2
Pond A-3
Pond A-4
Pond B-1
Pond B-2
Pond B-3
Pond B-4
Pond B-5
Solar Evaporation Ponds
W6 W7 W8 W9 W10 W11 W12 W13 W14 W15 W16 W17 W18 W19 W20 W21 W22 W23 W24 W25 W26 W27 W28
T1 T2 T3 T7 T8 T9 T10 T11 T12 T13 T14 T15 T16 T17 T18 T19 T20 T21 T22
S1 S2 S3 S4 S5 S6 S7 S8 S9 S10
PW10894 PW12094 PW41091 PW41691 PW10694 PW3886 PW1586
0686 53194 4287
X PW114389 and T4,T5, and T6 Locations are off map, 2,950 ft. W. 1,300 ft. S. (On Walnut Creek, Northwestern-most boundary of Industrial Area)
Legend
W18 Groundwater Flow Piezometer
S9 Seep/Spring Piezometer
T20 Aquifer Testing Piezometer
PW41091 Aquifer Testing Pumping Well
Dirt Roads
U.S. Department of Energy
RFETS, Golden, Colorado
Seepage Characterization Project
Well-Point Location Map
North East Buffer Zone
Figure 2a
Status: March 1995
GRSF2A.DWG